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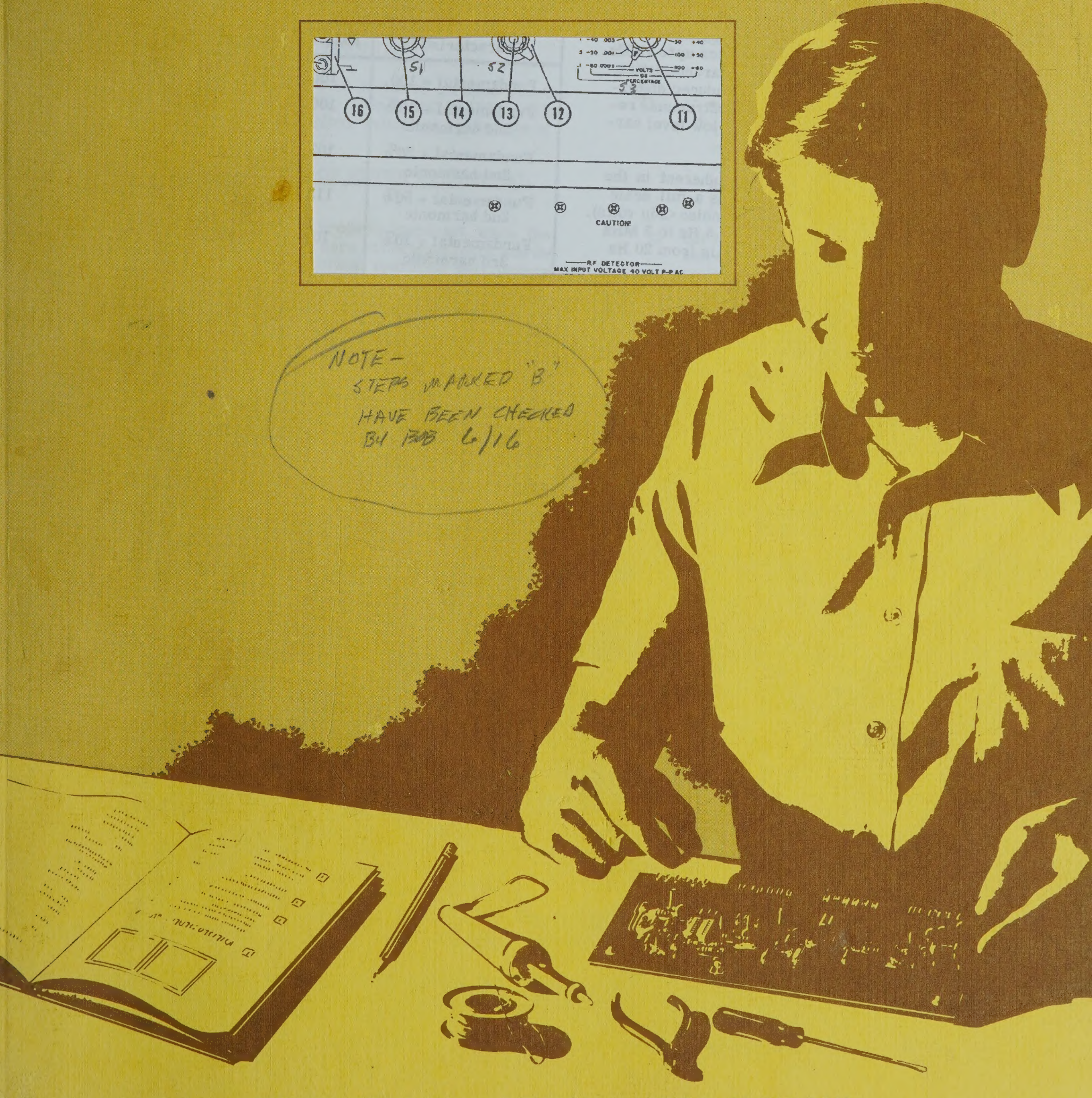

NOTE-
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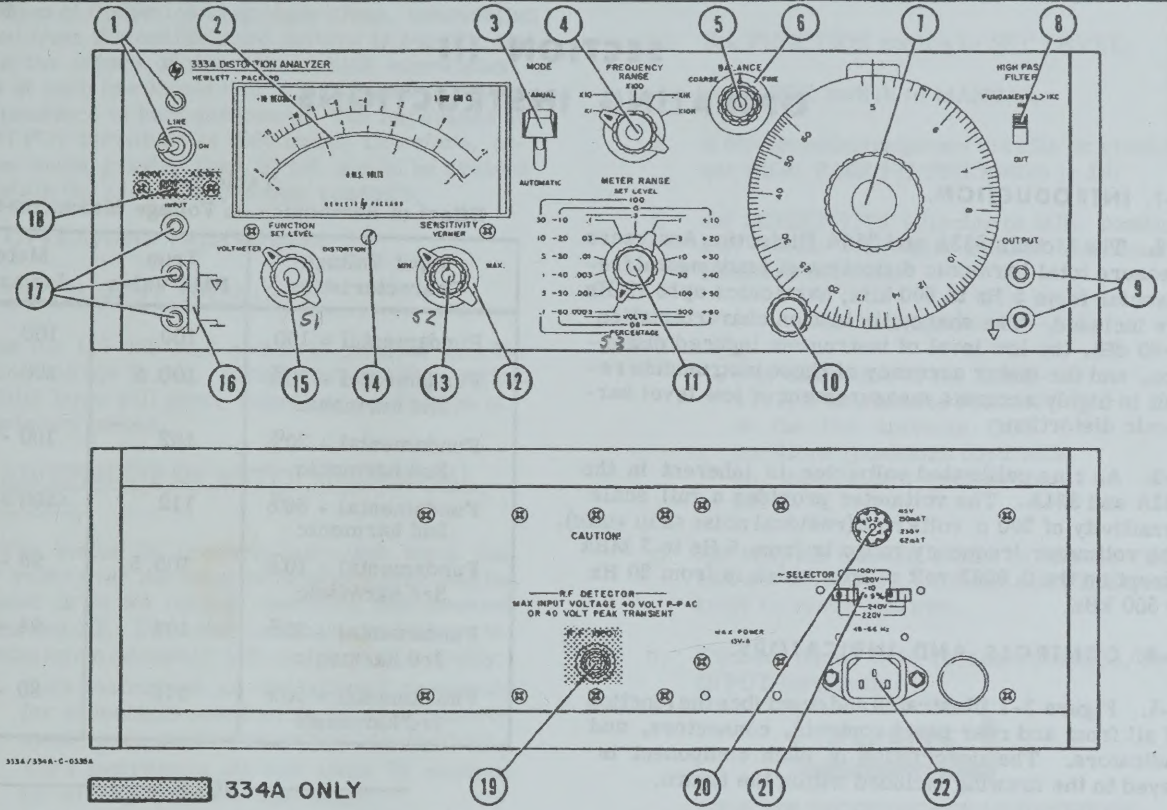

① **LINE switch turns instrument ac power on. Pilot lamp glows when instrument is turned ON.**

② **Meter indicates distortion or voltage level of input.**

③ **MODE switch selects MANUAL or AUTOMATIC bridge tuning operation.**

④ **FREQUENCY RANGE switch selects frequency range which corresponds to fundamental of input signal.**

⑤ **COARSE BALANCE control provides coarse adjustment for balancing the Wien bridge circuit.**

⑥ **FINE BALANCE control provides a vernier adjustment for balancing the Wien bridge circuit.**

⑦ **Frequency dial tunes the Wien bridge circuit to fundamental of input signal.**

⑧ **HIGH PASS FILTER switch inserts or bypasses HIGH PASS FILTER in SET LEVEL and DISTORTION function. When inserted, filter provides > 40 dB attenuation to 50 - 60 Hz hum components but no attenuation to frequencies over 1 kHz.**

⑨ **OUTPUT connectors provide means of monitoring output of meter circuit.**

⑩ **Frequency vernier provides fine adjustment of frequency dial.**

⑪ **METER RANGE switch selects full scale range of meter in percent, dB and rms volts.**

⑫ **SENSITIVITY selector provides 0 - 50 dB attenuation of input signal in 10 dB steps in SET LEVEL and DISTORTION functions.**

⑬ **SENSITIVITY VERNIER control provides fine adjustment of sensitivity setting.**

⑭ **Mechanical zero adjust provides mechanical zero adjustment of meter.**

⑮ **FUNCTION switch selects type of operation of instrument.**

⑯ **Shorting bar connects circuit ground to chassis ground.**

⑰ **INPUT terminals provide connections for input signal.**

⑱ **NORM RF DET (Model 334A only) selects front panel INPUT or rear panel RF INPUT connector.**

⑲ **RF INPUT connector (Model 334A only) provides input connection for AM RF carrier input signal.**

⑳ **FUSE provides current overload protection for instrument circuits.**

㉑ **Line voltage switch sets instrument to operate from 100 V/120 V/220 V/240 V.**

㉒ **Ac power connector provides input connection for ac power.**

Figure 3-1. Front and Rear Panel Description

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Models 333A and 334A Distortion Analyzers measure total harmonic distortion of fundamental frequencies from 5 Hz to 600 kHz; harmonics up to 3 MHz are included. The sharp elimination characteristics (>80 dB), the low level of instrument induced distortion, and the meter accuracy of these instruments result in highly accurate measurement of low level harmonic distortion.

3-3. An rms calibrated voltmeter is inherent in the 333A and 334A. The voltmeter provides a full scale sensitivity of 300 μ volts rms (residual noise $<25\mu$ volts). The voltmeter frequency range is from 5 Hz to 3 MHz except on the 0.0003 volt range, which is from 20 Hz to 500 kHz.

3-4. CONTROLS AND INDICATORS.

3-5. Figure 3-1 illustrates and describes the function of all front and rear panel controls, connectors, and indicators. The description of each component is keyed to the drawing included within the figure.

3-6. GENERAL OPERATING INFORMATION.

3-7. INPUT CONNECTIONS.

3-8. The input signal can be connected to the 333A and 334A through twisted pair leads or a shielded cable with banana plug connectors. Keep all test leads as short as possible to avoid extraneous pickup from stray ac fields. When measuring Low-level signals, ground loops may occur causing erroneous readings. Ground loops may be avoided by connecting the 333A/334A Distortion Analyzer to an appropriate isolation transformer to break the chassis ground from power supply ground. Connect all other instruments to one power strip with the three-prong connectors as close as possible.

3-9. VOLTMETER CHARACTERISTICS.

3-10. The RMS VOLTS markings on the meter face are based on the ratio between the average and effective (rms) values of a pure sine wave. The ratio of average to effective values in a true sine wave is approximately 0.9 to 1. When the meter is used to measure complex waves, the voltage indicated may not be the rms value of the signal applied. This deviation of meter indication exists because the ratios of average to effective values are usually not the same in a complex wave as in a sine wave. The amount of deviation depends on the magnitude and phase relation between the harmonics and fundamental frequency of the signal applied. Table 3-1 lists the deviation of the meter indication of a sine wave partly distorted by harmonics. As indicated in the table, harmonic content of less than 10% results in very small errors.

Table 3-1
Effect of Harmonics on Voltage Measurements

Input Voltage Characteristics	True RMS Value	Meter Indication
Fundamental = 100	100	100
Fundamental + 10% 2nd harmonic	100.5	100
Fundamental + 20% 2nd harmonic	102	100 - 102
Fundamental + 50% 2nd harmonic	112	100 - 110
Fundamental + 10% 3rd harmonic	100.5	96 - 104
Fundamental + 20% 3rd harmonic	102	94 - 108
Fundamental + 50% 3rd harmonic	112	90 - 116

NOTE

This chart is universal in application since these errors are inherent in all average-responding voltage-measuring instruments.

3-11. When making distortion measurements where the fundamental frequency is suppressed and the remainder of the signal is measured, the reading obtained on an average responding meter may deviate from the true total rms value. When the residual wave contains many inharmonically related sinusoids, the maximum error in the distortion reading is about 11 % (11 % of the measured distortion) low for distortion levels below 10 %.

EXAMPLE:

Measured Distortion	Maximum Error In Meter Indication	Total Distortion
2.5%	+0.11x0.025= 0.00027	0.025+0.0027= 0.0277 or 2.8%

This example represents the maximum possible error, and in most cases the error is less. In distortion measurements, the reading of an average-responding meter is sufficiently close to the rms value to be satisfactory for most applications.

3-12. OUTPUT TERMINALS.

3-13. The OUTPUT terminals provide a 0.1 V rms open circuit output for full scale meter deflection. These terminals can be used to monitor the output signal with an oscilloscope, a true rms voltmeter, or a wave analyzer. The combination of the distortion meter and oscilloscope provides more significant information about the device under test than the expression of distortion magnitude alone. Information obtained from the oscilloscope pattern is specific and reveals the nature of distortion which sometimes occurs at such low levels that it is difficult to detect in the presence of hum and noise. The impedance at the OUTPUT terminals is 2000 ohms, therefore, capacitive loads greater than 50 pF should be avoided to maintain the accuracy of meter readings.

3-14. OPERATING PROCEDURES.

3-15. INSTRUMENT TURN-ON.

a. Set the 115-230 VAC switch to coincide with the line voltage in use. Turn switch to ON position. Pilot lamp will glow, indicating application of primary power.

3-16. ADJUSTMENT OF METER MECHANICAL ZERO.

3-17. The meter is properly zero-set when the pointer rests over the zero calibration mark and the instrument is in its normal operating enivronment and is turned off. Zero-set the meter as follows to obtain maximum accuracy and mechanical stability:

a. Turn instrument on and allow it to operate for at least 20 minutes, to let meter movement reach normal operating temperature.

b. Turn instrument off and allow 30 seconds for all capacitors to discharge.

c. Rotate zero adjustment screw clockwise until pointer is left of zero and moving upscale.

d. Continue rotating screw clockwise; stop when pointer is exactly at zero.

e. When pointer is exactly over zero, rotate adjustment screw slightly counterclockwise to relieve tension on pointer suspension. If pointer moves off zero, repeat steps c through e, but make counterclockwise rotation less.

3-18. DISTORTION MEASUREMENT.

CAUTION

DO NOT EXCEED THE INPUT VOLTAGES LISTED BELOW TO PREVENT DAMAGING COMPONENTS ON A2 BOARD.

VOLTMETER FUNCTION -1V RANGE AND BELOW, AND DISTORTION ANALYZER FUNCTION - MAXIMUM SENSITIVITY.

1. 300 V ABOVE 100 Hz
2. 50 V ABOVE 1 kHz

3-19. MANUAL MODE.

a. Turn instrument on and mechanically zero meter according to procedure in Paragraphs 3-15 and 3-16.

b. Set NORM-R. F. DET. switch to NORM.

c. Set FUNCTION switch to SET LEVEL.

d. Set MODE switch to MANUAL.

e. If fundamental frequency is 1 kHz or greater, set HIGH PASS FILTER switch to IN.

f. Set SENSITIVITY selector to MIN. position, and rotate VERNIER control maximum counterclockwise.

NOTE

The bandwidth of the SENSITIVITY selector is reduced in the two extreme CCW positions (positions used with an input signal greater than 30 V).

g. Set METER RANGE switch to SET LEVEL, and set BALANCE COARSE and FINE controls to center position.

h. Connect signal to be measured to 333A/334A INPUT terminals.

WARNING

REMOVE SHORTING STRAP BETWEEN FRAME GROUND (⊥) AND CHASSIS GROUND (⏚) TERMINALS ON FRONT PANEL INPUT TERMINALS WHEN MEASURING DISTORTION BETWEEN TWO POINTS WHICH ARE DC OFFSET FROM GROUND POTENTIAL.

i. Set SENSITIVITY selector to obtain meter indication greater than 1/3 full scale.

j. Adjust SENSITIVITY VERNIER for full scale meter indication if making distortion measurement in percent; if making distortion measurement in dB adjust SENSITIVITY VERNIER for 0 dB meter indication.

NOTE

If unable to adjust for full scale or 0dB indication, (which indicates input signal is below 0. 3 volts), set METER RANGE selector downscale. Use this new setting as the 100% or 0dB SET LEVEL position, thus making the next range 30% or -10 dB, etc.

k. Set FREQUENCY RANGE switch and frequency dial to fundamental frequency of input signal.

l. Set FUNCTION switch to DISTORTION.

m. Adjust frequency dial vernier and BALANCE COARSE and FINE controls for minimum meter indication. Set METER RANGE switch down-scale as necessary to keep meter indication on scale.

n. Repeat step m until no further reduction in meter indication can be obtained.

o. Observe distortion either in percentage or dB, as indicated by meter deflection and METER RANGE switch setting. For example, if meter indicates 0.4 and METER RANGE setting is 1%, distortion measured is 0.4% of fundamental. Similarly, if meter indicates -6 dB and METER RANGE setting is -40 dB, distortion measured is -46 dB from fundamental.

NOTE

In MANUAL mode the accuracy of distortion measurements is affected by frequency stability of the input signal. An inaccuracy in distortion indications occurs when the frequency drift of the input signal exceeds the bandwidth of the rejection curve.

p. If desired, rms voltage of input signal can be measured by setting FUNCTION switch to VOLTMETER, and setting METER RANGE switch to obtain an on-scale indication.

3-20. AUTOMATIC MODE.

a. Perform steps a through l of Paragraph 3-19.

b. Adjust frequency dial vernier and BALANCE COARSE and FINE controls for minimum meter indication.

c. When meter indication is less than 10% of SET LEVEL indication, set MODE switch to AUTOMATIC. (If fundamental cannot be manually nulled below 10% of SET LEVEL indication, automatic mode cannot be used).

d. Set METER RANGE switch down-scale to obtain on-scale meter indication.

e. Observe distortion either in percentage or dB, as indicated by meter deflection and METER RANGE switch setting. For example, if meter indicates 0.4 and METER RANGE setting is 1%, distortion measured is 0.4% of fundamental. Similarly, if meter indicates -6 dB and METER RANGE setting is -40 dB, distortion measured is -46 dB from fundamental.

f. If desired, rms voltage of input signal can be measured by setting FUNCTION switch to VOLTMETER, and setting METER RANGE switch to obtain an on-scale indication.

3-21. DISTORTION MEASUREMENT OF AM RF CARRIERS (334A only).

CAUTION

DO NOT EXCEED MAXIMUM INPUT VOLTAGES LISTED ON REAR PANEL.

a. Turn instrument on and mechanically zero meter according to procedure in Paragraphs 3-15 and 3-16.

b. Set NORM.-R. F. DET. switch to R. F. DET.

c. Connect input signal to R. F. INPUT terminal on rear panel.

d. Refer to Paragraph 3-19 for manual distortion measurement; refer to Paragraph 3-20 for automatic distortion measurement.

NOTE

If no meter deflection can be obtained with an RF input, diode A4CR1 should be checked. A spare diode is located on the outside of the A4 shield.

3-22. VOLTAGE MEASUREMENT.

a. Turn instrument on and mechanically zero meter according to procedure in Paragraphs 3-15 and 3-16.

b. Set NORM.-R. F. DET. switch to NORM.

c. Set FUNCTION switch to VOLTMETER.

d. Set METER RANGE switch to a range exceeding amplitude of signal to be measured.

e. Connect signal to be measured to INPUT terminals.

f. Set METER RANGE switch to give a reading as close to full scale as possible, and observe meter indication.

g. The dB scale of the 333A/334A is calibrated in dBm, such that 0 dBm = 1 milliwatt dissipated by 600 ohms. Therefore, a dBm measurement must be made across 600 ohms. However, dB measurements across other impedances can be converted to dBm by use of the Impedance Correction Graph of Figure 3-3. For example: to convert a -30 dB reading across 200 ohms to dBm, locate the 200 ohm impedance line at the bottom of the graph. Follow the impedance line to the heavy black line, and read the meter correction at that point. The correction for 200 ohms is +5 dBm; thus the corrected reading is -25 dBm.

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3-23. METER INDICATION.

3-24. The 333A/334A meter is calibrated to indicate in both dB and volts. It is interesting to note that the METER RANGE markings differ from most ac voltmeter range markings. On most ac voltmeters (600 ohms) 0 dB corresponds to the 1 volt range. This is not true in the case of the 333A/334A. Since the instrument is primarily a distortion analyzer, measurements are in dB (relative measurement) rather than in dBm (absolute measurement). Zero dB on the 333A/334A corresponds to 0.3 volt range rather than the 1 volt range. This allows a 10 dB greater dynamic range of distortion measurements.

3-25. If measurements are to be made in dBm, 10 dB must be subtracted from the METER RANGE setting. Thus 0 dB becomes the -10 dBm range for absolute power measurements. Zero dBm is equal to 1 milliwatt dissipated by any impedance and in this particular case is 600 ohms. The +10 DECIBELS marking on the meter face indicates that when voltmeter measurements are being made, the indication (METER RANGE plus meter indication) is 10 dB greater than when power (dBm) measurements are being made.

3-26. In short, when distortion and voltage measurements are being made, utilize the instrument METER RANGE and meter scale as they exist. For absolute power measurements in dBm, simply subtract 10 dB from the METER RANGE setting.

3-27. USE OF OUTPUT TERMINALS.

3-28. In VOLTMETER and SET LEVEL functions, the 333A/334A can be used as a low distortion, wide-band amplifier. A portion of the meter input (0.1 V rms open circuit for full scale meter deflection is provided at the OUTPUT terminals.

3-29. In DISTORTION function, the distortion (0.1 V rms open circuit for full scale deflection) is provided at the OUTPUT terminals for monitoring purposes.

NOTE

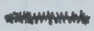
The INPUT ⏚ terminal and the OUTPUT ⏚ terminal should not be connected directly together when making low level measurements. These terminals are isolated from each other by 1 ohm which reduces the effects of common mode voltages.

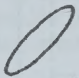
3-30. 333A/334A WITH OPTION 01.

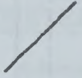
3-31. Operating procedures for the 333A/334A with Option 01 are the same as for the standard instrument. The only difference between the standard and optional instrument is that the Option 01 has a special meter and meter amplifier which is compensated to respond to VU (volume unit) characteristics.

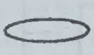
3-32. MANUAL NULLING.

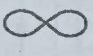
3-33. Since the frequency and balance controls are rather sensitive in the MANUAL mode, the following information is supplied to simplify nulling the 333A/334A in the MANUAL mode. When nulling the 333A/334A in the MANUAL mode, connect the equipment as shown below and adjust the 333A/334A frequency and balance controls for the waveform shown in step a below. Additional waveforms are provided to simplify nulling.

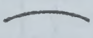
a.  No harmonic distortion. Frequency and balance adjustment correct.

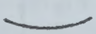
b.  Frequency and balance control improperly adjusted.

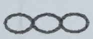
c.  Frequency approximately correct; balance incorrect.

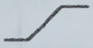
d.  Balance approximately correct; frequency incorrect.

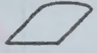
e.  Second harmonic predominant; frequency and balance adjusted.

f.  Second harmonic predominant; frequency and balance adjusted; phase changed.

g.  Second harmonic predominant; frequency and balance adjusted; phase changed.

h.  Third harmonic predominant.

i.  Balance incorrect; meter reading of scale.

j.  Frequency incorrect; meter readin off scale.

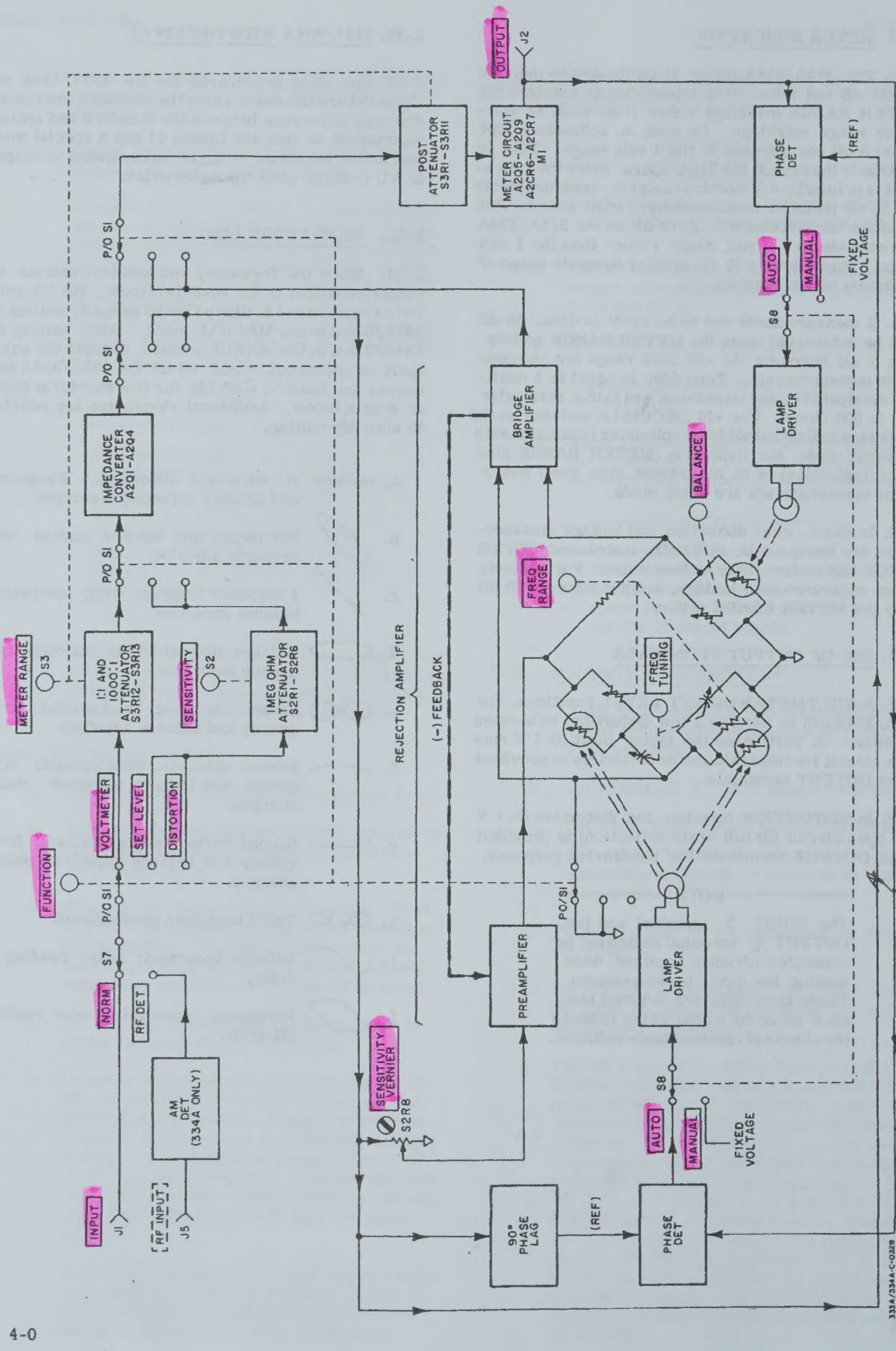
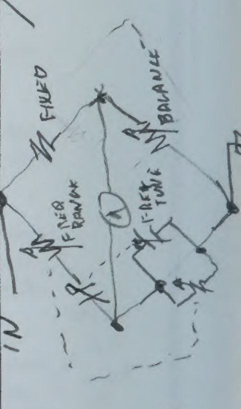


Figure 4-1. Block Diagram



SECTION IV

THEORY OF OPERATION

4-1. OVERALL DESCRIPTION.

4-2. Models 333A and 334A Distortion Analyzers include an impedance converter, a rejection amplifier, a metering circuit, and a power supply. The Model 334A also contains an AM detector. The impedance converter provides a low noise input circuit with a high input impedance independent of source impedance placed at the INPUT terminals. The rejection amplifier rejects the fundamental frequency of the input signal and passes the remaining frequency components on to the metering circuit for measuring distortion. The metering circuit provides visual indications of distortion and voltage levels on the front panel meter, M1. The AM detector (Model 334A only) detects the modulating signal from the RF carrier and filters all RF components from the modulating signal before it is applied to the impedance converter circuit.

4-3. BLOCK DIAGRAM DESCRIPTION.

(Refer to Figure 4-1)

4-4. DISTORTION MEASURING OPERATION.

4-5. For distortion measurement, the input signal is applied to the impedance converter (Assembly A2) through the FUNCTION selector, S1, and the one megohm attenuator. The one megohm attenuator is a voltage divider network which provides 50 dB attenuation in 10 dB steps. The desired level of attenuation is selected by the SENSITIVITY selector, S2. The impedance converter provides impedance matching and unity gain between the INPUT terminals and the input of the rejection amplifier.

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4-6. The rejection amplifier consists of a preamplifier, a Wien bridge, and a bridge amplifier. The SENSITIVITY VERNIER control, at the input of the preamplifier, provides a set level signal to obtain a full scale reading on the meter for any voltage level at the input of the instrument. With the FUNCTION switch in the SET LEVEL position, a ground is applied to the Wien bridge circuit to allow a signal reference level to be set up on the meter. With the FUNCTION switch in the DISTORTION position, the Wien bridge is used as an interstage coupling network between the preamplifier and bridge amplifier. The Wien bridge is then tuned and balanced to reject the fundamental frequency of the applied input signal. Two automatic control loops consisting of two phase detectors, lamp drivers, lamps, and photocells provide fine tuning and balance in the AUTOMATIC MODE. The remaining frequency components are applied to the bridge amplifier and are measured as distortion by the metering circuit. Negative feedback from the bridge amplifier to the preamplifier narrows the rejection response of the Wien bridge.

4-7. The output of the rejection amplifier is applied to the metering circuit through the post-attenuator. The post-attenuator is used to limit the input signal level applied to the metering circuit to 1 mV for full scale deflection. Sensitivity of the metering circuit is increased to 300 μV for full scale deflection on the .0003 V range. The metering circuit provides a visual indication of the distortion level of the input signal. In addition to the indication provided by the meter, the OUTPUT terminals provide a means of monitoring the distortion components.

4-8. DISTORTION MEASUREMENT IN AM CARRIERS.

4-9. The Model 334A Distortion Analyzer contains an AM detector circuit for measuring envelope distortion in AM carriers. The input signal is applied to the input of the AM detector circuit where the modulating signal is recovered from the RF carrier. The signal is then applied to the impedance converter circuit through the one megohm attenuator and then through the same circuits previously described in the distortion measuring mode operation.

4-10. VOLTMETER OPERATION.

4-11. In the voltmeter mode of operation, the input signal is applied to the impedance converter circuit through the 1:1 and 1000:1 attenuator. The 1:1 attenuation ratio is used on the 0.0003 to 0.3 VOLTS ranges, and the 1000:1 attenuation ratio is used in the 1 to 300 VOLTS ranges. With the FUNCTION switch in the VOLTMETER position, the output of the impedance converter bypasses the rejection amplifier and is applied to the metering circuit through the post-attenuator (METER RANGE switch). Metering circuit sensitivity is increased from 1 mV for full scale deflection to 300 μV on the .0003V range, as it was in the distortion measuring operation. The function of the post-attenuator and metering circuit is the same for voltmeter operation as for the distortion measuring operation.

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4-12. DETAILED CIRCUIT DESCRIPTION.

4-13. IMPEDANCE CONVERTER CIRCUIT.

(Refer to Figure 7-2)

4-14. The input signal is applied to the impedance converter circuit through the 1:1 and 1000:1 attenuator S3R12 in voltmeter operation, and through the one megohm attenuator S2R1 through S2R6 in distortion operation. Capacitive dividers S2C1 through S2C10 in the attenuator keep the frequency response flat. The impedance converter is a low distortion, high input impedance amplifier circuit with gain independent of the source impedance placed at the INPUT terminals.

MTR RANGE

SENSITIVIT

4-15. Instrument induced distortion of the signal being measured is minimized by keeping the input impedance and the gain of the impedance converter linear. The input impedance is kept linear by use of local positive feedback from the source of A2Q1 to the gate of A2Q1 and to the protective diodes A2CR2 and A2CR3. Thus signals with a large source impedance can be measured accurately. Overall induced distortion is further minimized by a high open loop gain and 100% negative feedback. The high open loop gain is achieved by local positive feedback from the emitter of A2Q3 to the collector of A2Q2. Overall negative feedback from the emitter circuit of A2Q4 to the source of A2Q1 results in unity gain from the impedance converter.

4-16. The bias points of the transistors in the impedance converter are selected to minimize instrument induced distortion. A2Q1, an extremely low noise, high impedance field effect transistor, is the major component that makes linearity of the impedance converter independent of the signal source impedance.

4-17. REJECTION AMPLIFIER CIRCUIT.

(Refer to Figures 7-3 and 7-5)

4-18. The rejection amplifier circuit consists of the preamplifier (A3Q1 thru A3Q3), the Wien bridge resistive leg and auto control loop (A5Q1 thru A5Q9 with associated lamp and photocell), the reactive leg and auto control loop (A5Q10 thru A5Q18 with associated lamp and photocell), and the bridge amplifier (A3Q4 thru A3Q6).

4-19. PREAMPLIFIER CIRCUIT.

4-20. The signal from the impedance converter is applied to the preamplifier, which is used during SET LEVEL and DISTORTION measuring operations. Negative feedback from the junction of A3R10 and A3R11 is applied to the junction of A3R2 and A3C2 to establish the operating point for A3Q1. Negative feedback from the emitter of A3Q3 is applied to the emitter of A3Q1 to stabilize the preamplifier. The preamplifier, like the impedance converter, is designed for high open loop gain and low closed loop gain to minimize instrument induced distortion.

4-21. WIEN BRIDGE CIRCUIT.

4-22. In the distortion measuring operation the Wien bridge circuit is used as a rejection filter for the fundamental frequency of the input signal. With the FUNCTION selector, S1, in the DISTORTION position, the Wien bridge is connected as an interstage coupling network between the preamplifier circuit and the bridge amplifier circuit. The bridge is tuned to the fundamental frequency of the input signal by setting the FREQUENCY RANGE selector, S4, for the applicable frequency range, and tuning the capacitors C4A through C4D. The bridge circuit is balanced by adjusting the COARSE balance control, R4, and the FINE balance control, R5. In the AUTOMATIC MODE fine tuning and balancing are accomplished by photoelectric cells which are in the resistive and reactive legs of the Wien bridge. The error signals for driving the photocells are derived by detecting the bridge output using the input signal as a reference.

4-23. When the Wien bridge is not tuned exactly to the frequency to be nulled, a portion of the fundamental frequency will appear at the bridge output. The phase of this signal depends on which leg of the bridge is not tuned, or on the relative errors in tuning if neither is set correctly. The magnitude of the signal is proportional to the magnitude of the tuning error of either or both legs of the bridge.

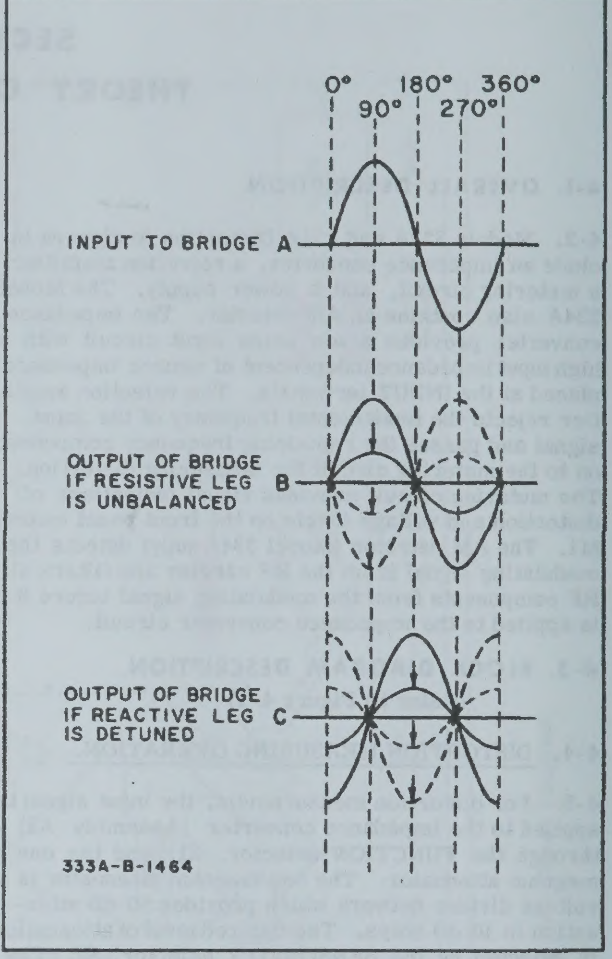
0°
180°
360°
90°
270°
INPUT TO BRIDGE A
OUTPUT OF BRIDGE IF RESISTIVE LEG IS UNBALANCED B
OUTPUT OF BRIDGE IF REACTIVE LEG IS DETUNED C
333A-B-1464

Figure 4-2. Bridge Waveforms

4-24. Figure 4-2a shows a sinusoid input to the Wien bridge. If the resistive leg of the bridge is slightly unbalanced, the output of the bridge is very small, but has the waveform shown in Figure 4-2b and is in phase with the input. As the resistive leg is tuned, the signal approaches zero amplitude at null and then becomes larger, but 180° out of phase, if the null position is passed. When the resistive leg is correctly tuned and the reactive leg is tuned through null, a similar waveform is produced, Figure 4-2c. The only difference is that the reactive signal is 90° out of phase with the resistive signal.

4-25. When the bridge output is detected using the input signal as the reference, the error signals in phase or 180° out of phase with the reference develop a voltage that is used to vary the resistance in the resistive leg of the bridge, to tune it to the correct null position. Signals of the form in Figure 4-2c do not develop any voltage, as the resistive detector is insensitive to inputs differing from the reference by 90°.

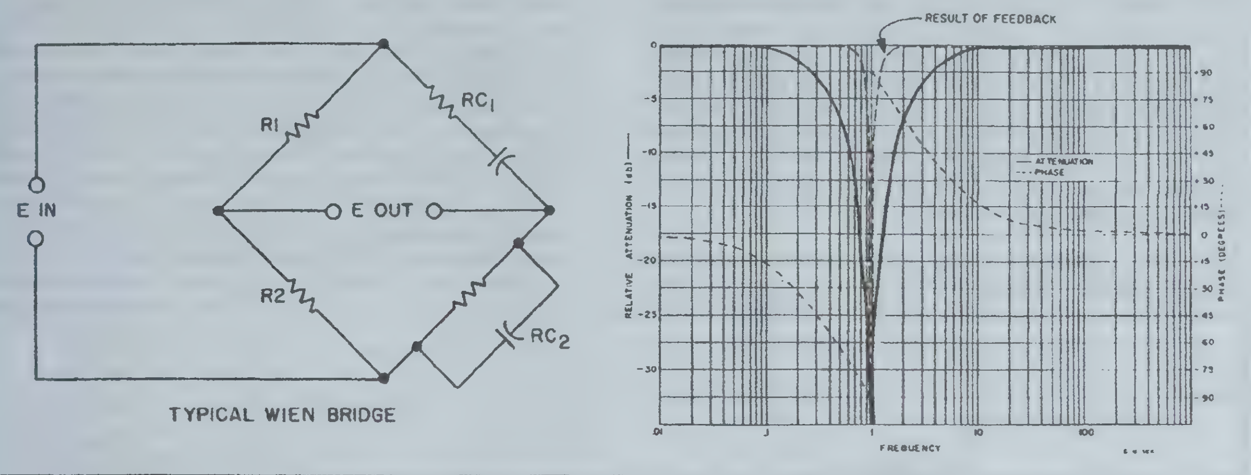

Figure 4-3. Wien Bridge Circuit and Rejection Characteristics

4-26. In an independent, but similar, control loop, the bridge input signal is shifted 90° and used as the reference signal for the detector. This detector develops control voltages to null the reactive leg of the bridge, but is insensitive to signals of the form in Figure 4-2b, which are caused by small tuning errors of the resistive branch.

4-27. The result is that the two control loops derive information from a common source and develop two independent control signals for nulling the two legs of the bridge. These control voltages are used to vary the brilliance of lamps, which in turn cause resistance changes in photocells that form part of the Wien bridge.

4-28. When the bridge circuit is tuned and balanced, the voltage and phase of the fundamental, which appears at junction of the series reactive leg (S4R1, 3, 5, 7, or 9 and C4A/B) and the shunt reactive leg (S4R11, 13, 15, 17, or 19, and C4C/D), is the same as at the midpoint of the resistive leg (A3R12 and A3R14). When these two voltages are equal and in phase, the fundamental frequency will not appear at the drain of the field effect transistor A3Q4. For frequencies other than the fundamental, the reactive leg of the Wien bridge offers various degrees of attenuation and phase shift which cause a voltage at the output points of the bridge. This difference voltage between the reactive leg and resistive leg is amplified by A3Q4, A3Q5, and A3Q6. Figure 4-3 illustrates a typical Wien bridge circuit and the rejection characteristics for it.

4-29. The Wien bridge circuit is designed to cover a continuous frequency range of over a decade for each position of the FREQUENCY RANGE selector S4. S4 provides coarse tuning of the reactive leg by changing the bridge circuit constants in five steps at 1 decade per step. For the automatic control loop, the reference voltage is taken from R6 at the input to the rejection amplifier and applied to the buffer amplifier A5Q7. The reference voltage is amplified and clipped by A5Q8 and A5Q9, and coupled to the detector A5Q4. The output of the metering circuit, which contains the fundamental frequency if either leg of the bridge is untuned, is applied to the buffer amplifier A5Q1. It is amplified by A5Q2 and A5Q3 and coupled to the detector A5Q4.

4-30. Refer to Figure 4-4, partial schematic for detector operation. The discussion is applicable to both resistive and reactive detector circuits.

4-31. The signals from the error amplifier, (A5Q2 and A5Q3) will be equal and of opposite phase, and will cancel out each other when the detector, A5Q4, is off. However, when the positive half of the reference square wave gates A5Q4 on, the signal from the collector of A5Q3 will be shorted to ground. Thus the signal from the collector of A5Q2 will be coupled through the filter network to the base of A5Q5. If the signal from A5Q2 is in phase with the reference, the positive half of the signal will be passed, and if it is out of phase, the negative half will be passed.

4-32. The normal working voltage at A5TP3 is between 0 and -1 volt. The dc output of the filter network causes the voltage at A5TP3 to go in a positive direction (toward zero) for in phase error signals, and in a negative direction (toward -1 V) for out of phase error signals. The change in base voltage is then amplified by A5Q5 and lamp driver A5Q6. This will change the brilliance of lamp A6DS1, which will vary the resistance of A6V1 in the direction necessary to balance the resistive leg of the bridge.

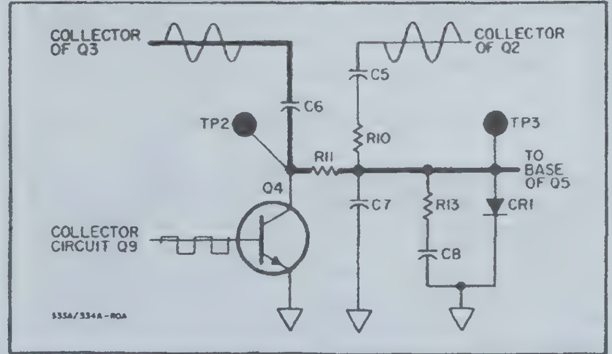

Figure 4-4. Auto Control Loop Detector

4-33. Refer to Figure 4-5 for the phase relationship of the bridge error signal and reference voltage at the base of A5Q4. The shaded portions of the error signals (b and c) indicate that part of the error signal which contributes to the dc lamp control voltage. As indicated in d, any error signal that is 90° out of phase with the reference does not affect the dc lamp control voltage, because equal amounts of the positive and negative portions are passed.

4-34. The operation of the reactive branch control loop is similar to that of the resistive branch. The phase delay circuit, A5Q15, A5Q16, S4AF and S4C1 through S4C5, shifts the reference voltage 90°, as shown in Figure 4-5f. This makes the detector A5Q12 sensitive to components of the bridge error signal that are 90° out of phase (g and h). The output of the lamp driver, A5Q14, controls the brilliance of A6DS2, which varies the resistance of A6V2 through A6V5 to tune the branches of the reactive leg. Deck AR of the FREQUENCY RANGE switch, S4, switches A5R56 in parallel with A5R55 on the top three frequency ranges. A6DS2 will become brighter, and lower the resistance of A6V2 through A6V5, making variation

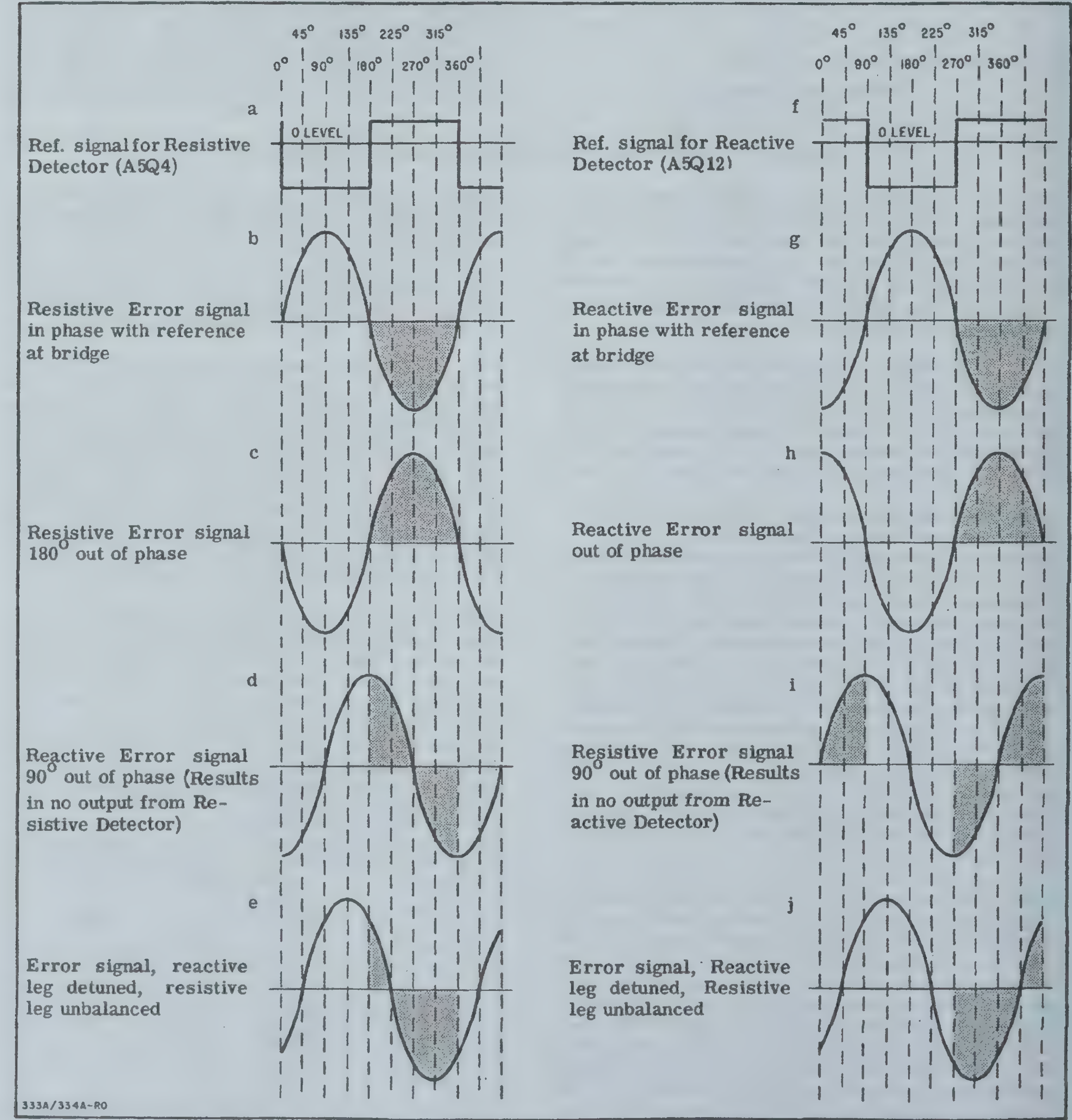
45° 135° 225° 315°
0° 90° 180° 270° 360°
a
Ref. signal for Resistive Detector (A5Q4)
0 LEVEL
b
Resistive Error signal in phase with reference at bridge
c
Resistive Error signal 180° out of phase
d
Reactive Error signal 90° out of phase (Results in no output from Resistive Detector)
e
Error signal, reactive leg detuned, resistive leg unbalanced
f
Ref. signal for Reactive Detector (A5Q12)
g
Reactive Error signal in phase with reference at bridge
h
Reactive Error signal out of phase
i
Resistive Error signal 90° out of phase (Results in no output from Reactive Detector)
j
Error signal, Reactive leg detuned, Resistive leg unbalanced
333A/334A-R0

Figure 4-5. Reference and Error Phase Relationship

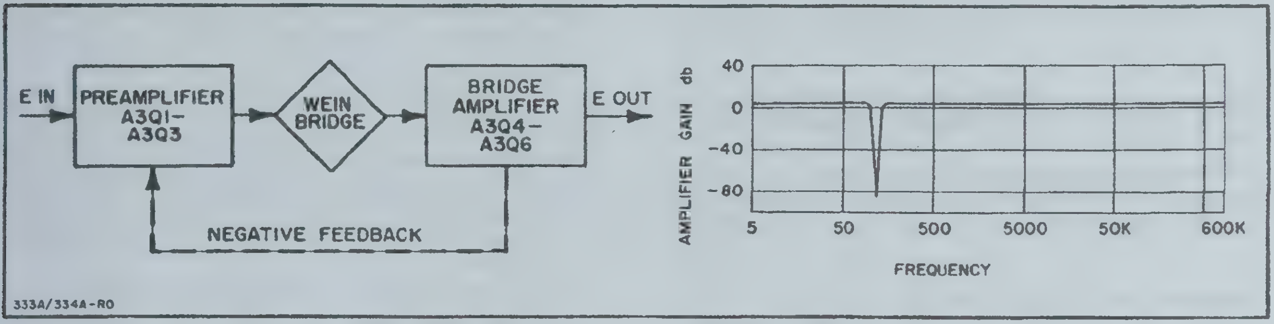

Figure 4-6. Rejection Amplifier Block Diagram and Typical Frequency Rejection Characteristic

in resistance less than on the two lower ranges. However, less variation in resistance is needed to tune the leg, because the impedance in the reactive leg becomes progressively less as the higher frequency ranges are selected.

4-35. Any error signal that is not an integral multiple of 90° is the result of the reactive leg of the bridge being detuned, and the resistive leg being unbalanced. For example, an error signal that is 45° out of phase (Figure 4-5e and j) will result in outputs from both resistive and reactive detectors to tune the bridge and reject the fundamental.

4-36. When the FUNCTION selector is set to the VOLTMETER or SET LEVEL position, the junction of the series and shunt reactive branches of the Wien bridge is connected to circuit ground through A3R19 by S1BF which disables the frequency rejection characteristic of the bridge circuit. With the bridge circuit disabled, the rejection amplifier circuit provides one dB of gain for the fundamental frequency and the harmonics. In the SET LEVEL operation, this signal is used to establish the SET LEVEL reference.

4-37. BRIDGE AMPLIFIER CIRCUIT.

4-38. The bridge amplifier circuit consists of three stages of amplification, A3Q4 through A3Q6. The first stage of amplification, A3Q4, is a field effect transistor which amplifies the difference signal between the gate and the source. The field effect transistor is selected for minimum noise performance with the high impedances of the Wien bridge circuit. The signal from the drain is applied to the two stage feedback amplifier A3Q5 and A3Q6. The output of A3Q6 is coupled to the meter circuit by the post attenuator S3R1 through S3R11. Negative feedback from the output of the bridge amplifier is applied to the preamplifier circuit to narrow the frequency rejection characteristic. It can be noted from the rejection characteristic (refer to Figure 4-3) for the bridge that the rejection of harmonic voltages is not constant. Typically the second harmonic is attenuated several dB more than the third harmonic and the third more than the fourth. The result of the negative feedback is illustrated by the rejection characteristic shown in dashed lines on the attenuation and phase characteristic of Figure 4-3. Figure 4-6 shows a simplified block diagram of the rejection amplifier with the typical frequency-rejection characteristic. Refer to Figure 4-7, Bandwidth Versus Null Depth for further detail on the rejection characteristic.

4-39. HIGH PASS FILTER.
(Refer to Figure 7-3).

4-40. The HIGH PASS FILTER is normally used when the fundamental of the input signal is greater than 1 kHz. In the voltmeter mode of operation, the filter is not used. In SET LEVEL and DISTORTION functions the filter presents > 40 dB attenuation to 50 or 60 Hz hum components, but offers no attenuation to frequencies over 1 kHz. The filter assembly, A7, consists of A7C1, A7C2, and A7L1. The filter can be inserted or bypassed by the HIGH PASS FILTER switch, S9.

4-41. METER AMPLIFIER.
(Refer to Figure 7-4)

4-42. The meter amplifier consists of the post attenuator, the meter amplifier circuit, and the meter rectifier circuit.

4-43. POST ATTENUATOR.

4-44. The post attenuator, S3R1 through S3R11, is a resistive network which attenuates the input signal in 10 dB steps. The attenuator is used in conjunction with either the input sensitivity attenuator or the 1000:1 attenuator to limit the signal level to the meter amplifier to 1 mV for full scale deflection on all ranges from 1 mV to 300 V full scale. The meter circuit sensitivity is increased to 300 μV for full scale deflection on the .0003V range by switching resistors A2R29 and A2R30 into the calibration network. Resistor A2R41 and capacitor A2C29 are also switched into the calibration network on the .0003V range to extend the passband of the amplifier.

4-45. METER AMPLIFIER CIRCUIT.

4-46. The meter amplifier circuit consists of a five stage amplifier circuit, A2Q5 through A2Q9, which develops the current for full scale meter deflection. Negative dc feedback from the emitter circuit of A2Q8 is applied to the base of A2Q5 to stabilize the dc operating point of the meter amplifier circuit and to minimize the tendency for dc drift due to ambient temperature changes. A2R51 and A2CR8 are electrically in the circuit only when the meter amplifier is overloaded. When the voltage on the emitter of A2Q9

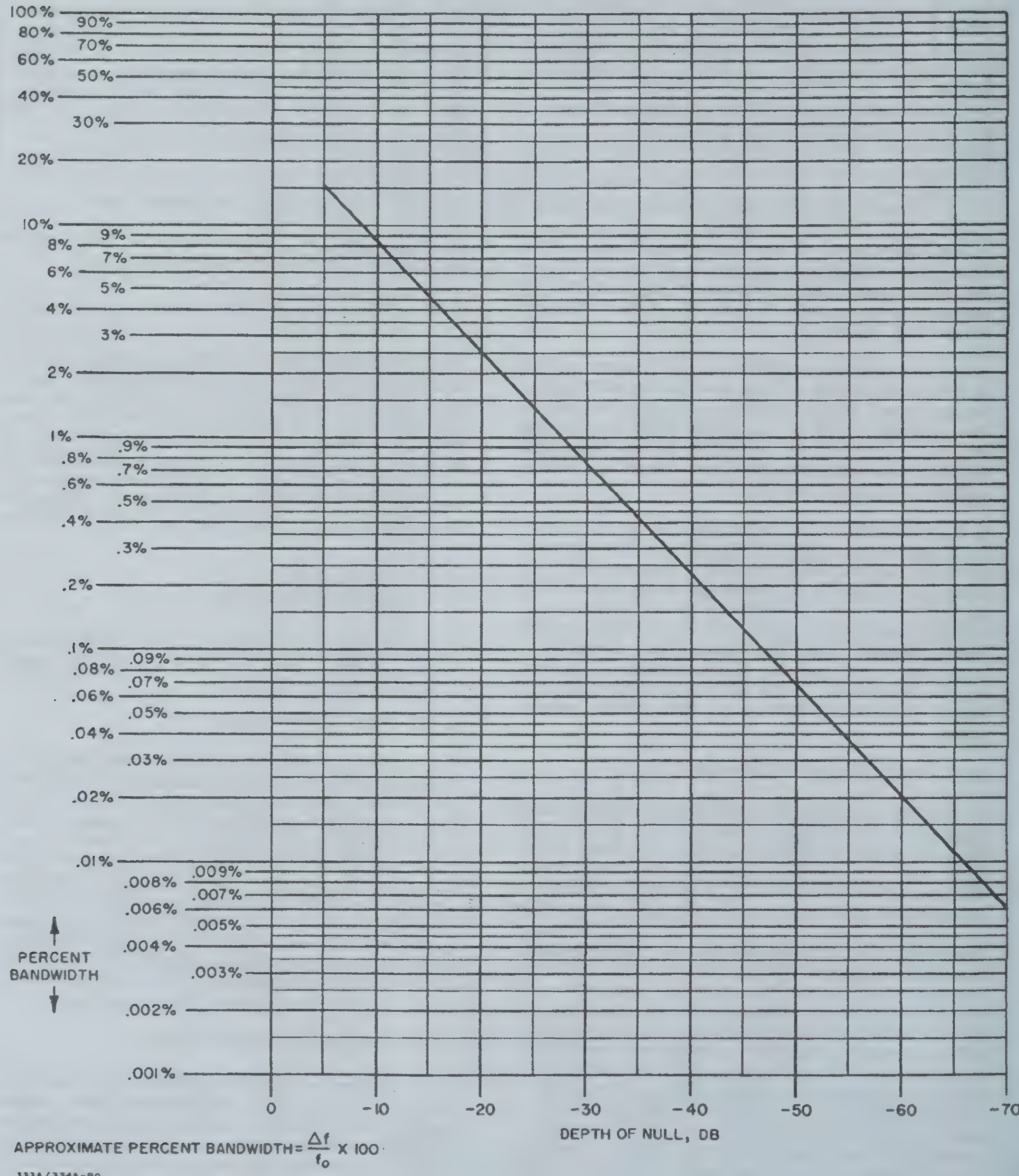

Figure 4-7. Bandwidth Versus Null Depth

becomes abnormally large during an overload, A2CR8 breaks down and provides a lower resistance charging path for A2C15, which reduces the transient recovery time of the meter amplifier. Negative ac feedback is applied from the collector circuit of A2Q9 to the emitter circuit of A2Q5. This feedback is used to ensure flat frequency response, to improve linearity, and to reduce the effect of variation of transistor parameters with environmental changes. In this manner, the calibration of the instrument is made dependent on high quality passive components.

4-47. METER RECTIFIER CIRCUIT.

4-48. The meter rectifier is connected in a bridge type configuration with a diode in each upper branch and a dc milliammeter connected across the midpoints of the bridge. The simplified meter rectifier is illustrated in Figure 4-8. The generator represented by A2Q5 through A2Q9 with the internal impedance R_0 provides the meter, M1, with current for full scale deflection and develops a voltage across the calibration network, which closes the ac feedback loop. Capacitors A2C27 and A2C28 are used as coupling capacitors for the ac feedback loop, output signal to the OUTPUT connector, and the bridge error signal to the input of the automatic fine tuning loops. The mechanical inertia of the meter and A2C26 prevents the meter from responding to individual current pulses. Therefore, the meter indication corresponds to the average value of the current pulses rather than the peak value. The meter is calibrated to indicate the rms value of a sine wave. Resistor A2R45 impresses a fixed bias across diodes A2CR6 and A2CR7 (biasing them close to the barrier voltage) to make the meter amplifier response linear to large variations in signal amplitude. The linearity of this type of circuit is also increased by including the meter circuit in the overall feedback loop.

4-49. POWER SUPPLY CIRCUIT.
(Refer to Figure 7-6)

4-50. The power supply circuit consists of a +25 volt series regulated supply and a -25 volt series regulated supply which is the reference supply for the +25 volt supply.

4-51. The -25 volt regulated supply is of the conventional series regulator type. The amplifier A1Q5 is used to increase the loop gain of the circuit, thus improving voltage regulation. The positive feedback applied to the junction of A1R11 and A1R12 is used to further improve the line frequency suppression of the circuit.

4-52. The +25 volt regulated supply is of the conventional series regulator type and operates the same as the -25 volt regulated supply.

4-53. RF DETECTOR CIRCUIT. (334A only)
(Refer to Figure 7-2)

4-54. The RF detector circuit consists of a rectifier, A4CR1, and filter circuit. The RF signal is applied to the circuit through the RF INPUT connector on the rear panel. The rectifier diode A4CR1 recovers the modulating signal from the RF carrier and the filter circuit removes any RF components before the signal is applied to the impedance converter circuit through the NORM-RF DET switch, S7.

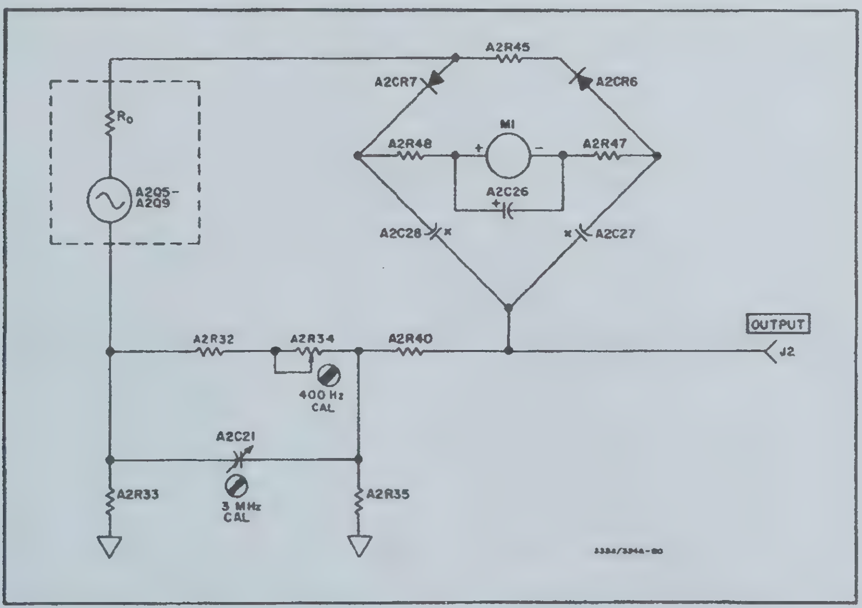

Figure 4-8. Simplified Metering Circuit

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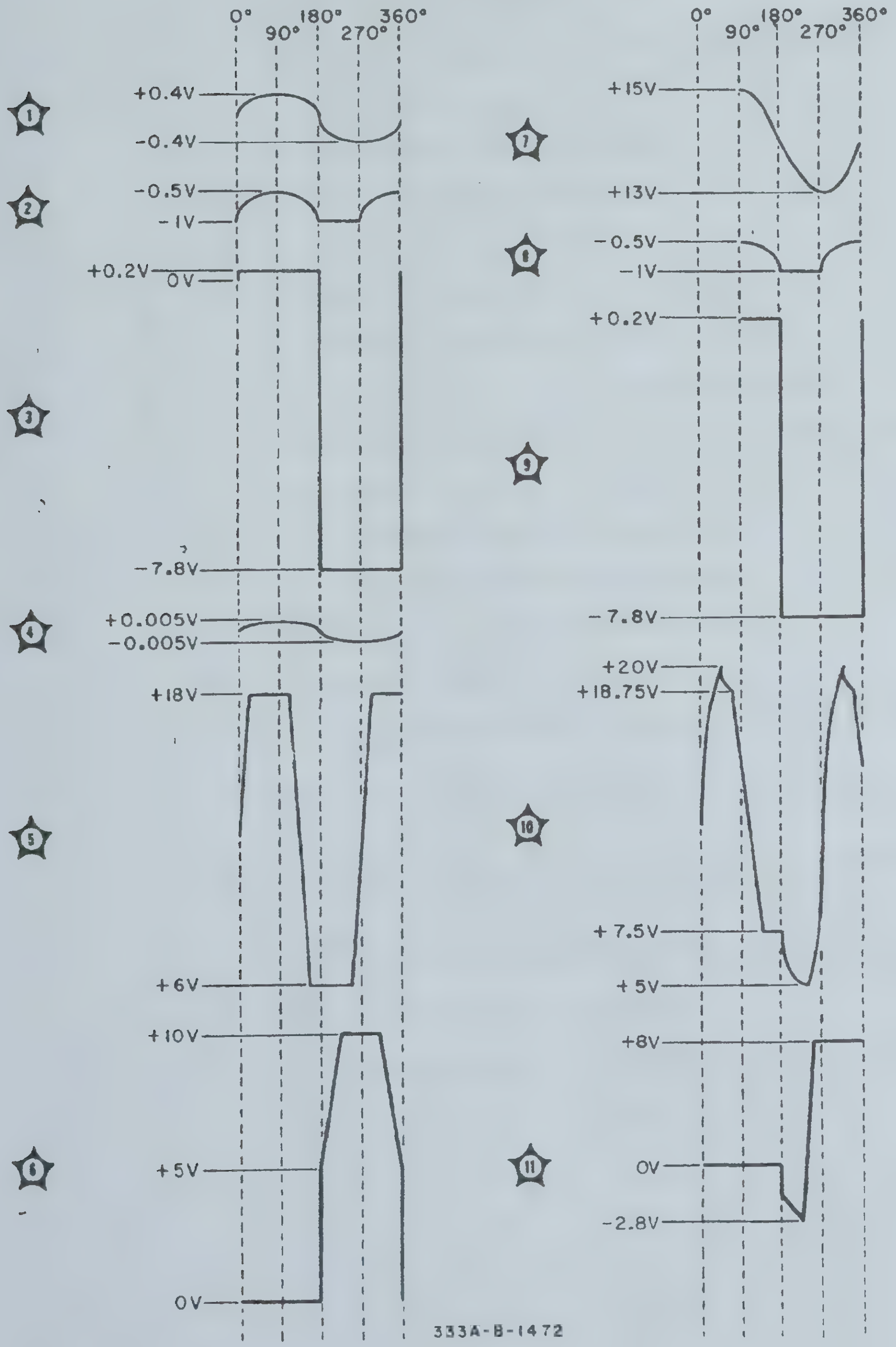
TROUBLESHOOTING INFORMATION

When checking the voltages and waveforms for this circuit, set the 333A/334A controls as follows, unless otherwise noted:

FUNCTION	SET LEVEL
METER RANGE	SET LEVEL
MODE	MANUAL
FREQUENCY RANGE	X100
Frequency Dial	10
Input Signal	1 kHz for full scale indication on 333A/334A meter



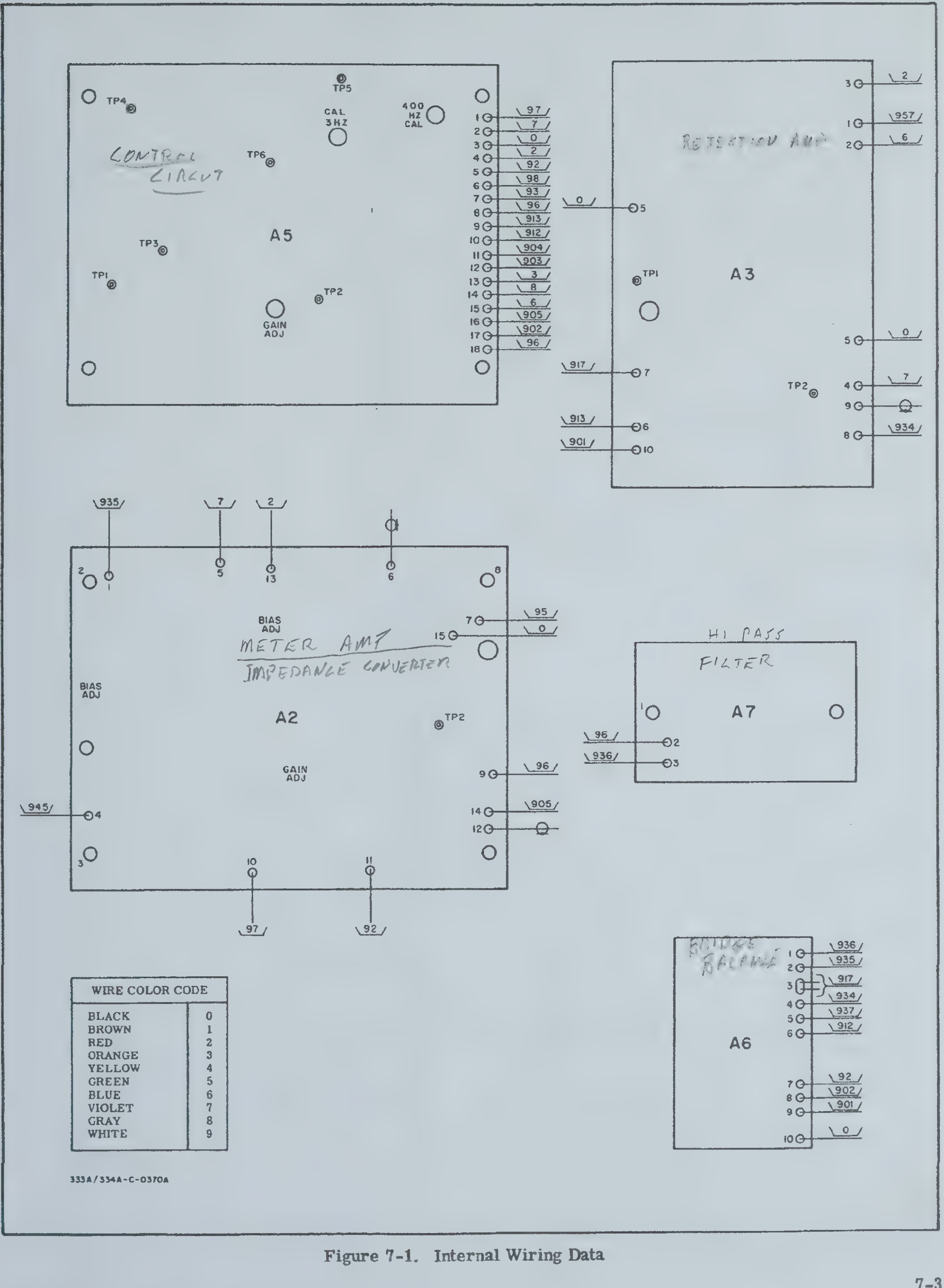
GENERAL SCHEMATIC NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED:

   RESISTANCE IN OHMS

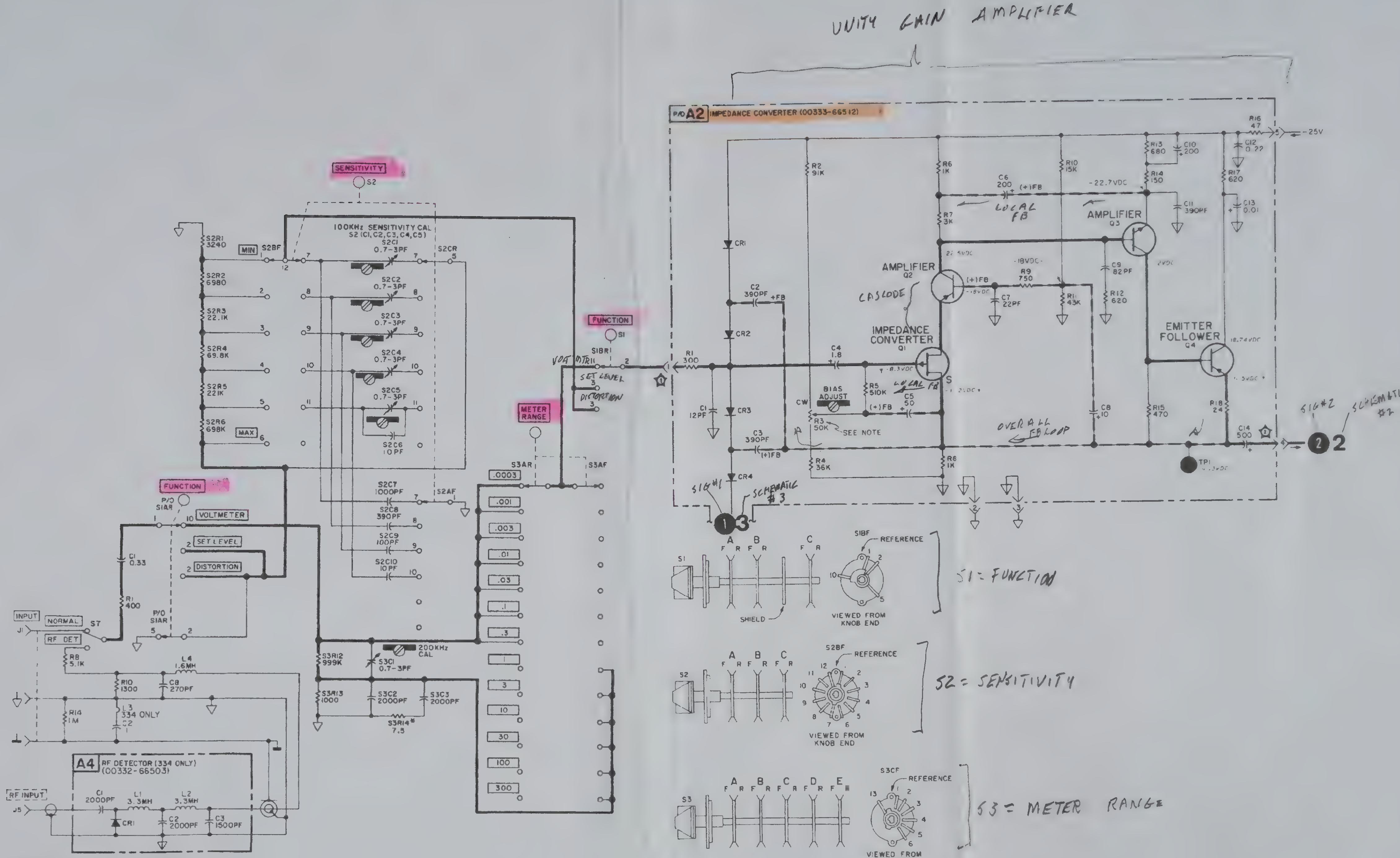
   CAPACITANCE IN MICROFARADS
3. ⊥ DENOTES FRAME GROUND.
4. ⏚ DENOTES EARTH GROUND.
5. ▽ DENOTES CHASSIS GROUND. (FLOATABLE)
6. ⏚ DENOTES CIRCUIT GROUND. (ON BOARD)
7. — — — ——— — — — DENOTES ASSEMBLY.
8. ━━━━━━━━ DENOTES MAIN SIGNAL PATH.
9. ━ ━ ━ ━ ━ ━ ━ DENOTES FEEDBACK PATH.
10. ☐ DENOTES FRONT PANEL MARKING.
11. ⬚ DENOTES REAR PANEL MARKING.
12. ⊘ DENOTES SCREWDRIVER ADJUST.
13. ○ DENOTES FRONT PANEL CONTROL.
14. ✱ AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.
15. ▨ DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
16. ☆ DENOTES TROUBLESHOOTING INFORMATION LOCATED ON APRON PAGE OF RESPECTIVE SCHEMATIC.
17. † DENOTES DC VOLTAGE THAT MUST BE MEASURED WITH 10 MΩ/10 pF IMPEDANCE PROBE TO PREVENT OSCILLATIONS.
18. ❶ DENOTES SIGNAL CONNECTION.
19. 1 DENOTES SCHEMATIC ON WHICH SIGNAL CONNECTION IS MADE.

HARMONIC
HP 333A DIST MTR



WIRE COLOR CODE	
BLACK	0
BROWN	1
RED	2
ORANGE	3
YELLOW	4
GREEN	5
BLUE	6
VIOLET	7
GRAY	8
WHITE	9

Figure 7-1. Internal Wiring Data



3334/334A-D-0329 B

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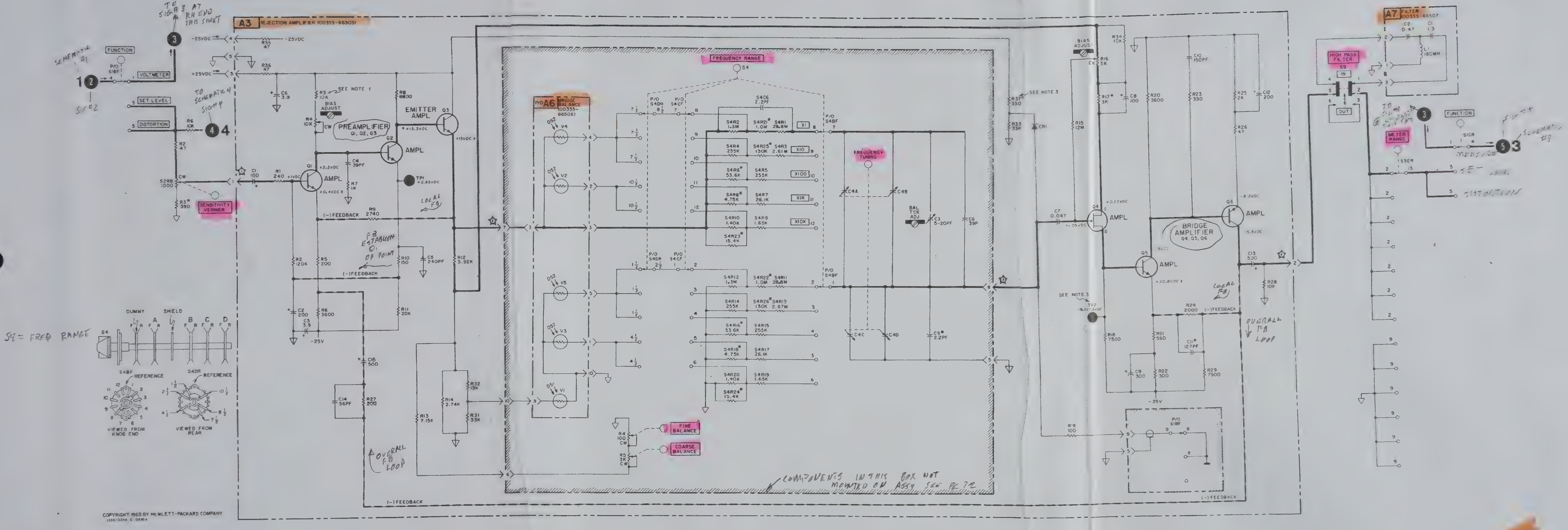
Figure 7-2. Impedance Converter (P/O A2) and RF Detector (A4)



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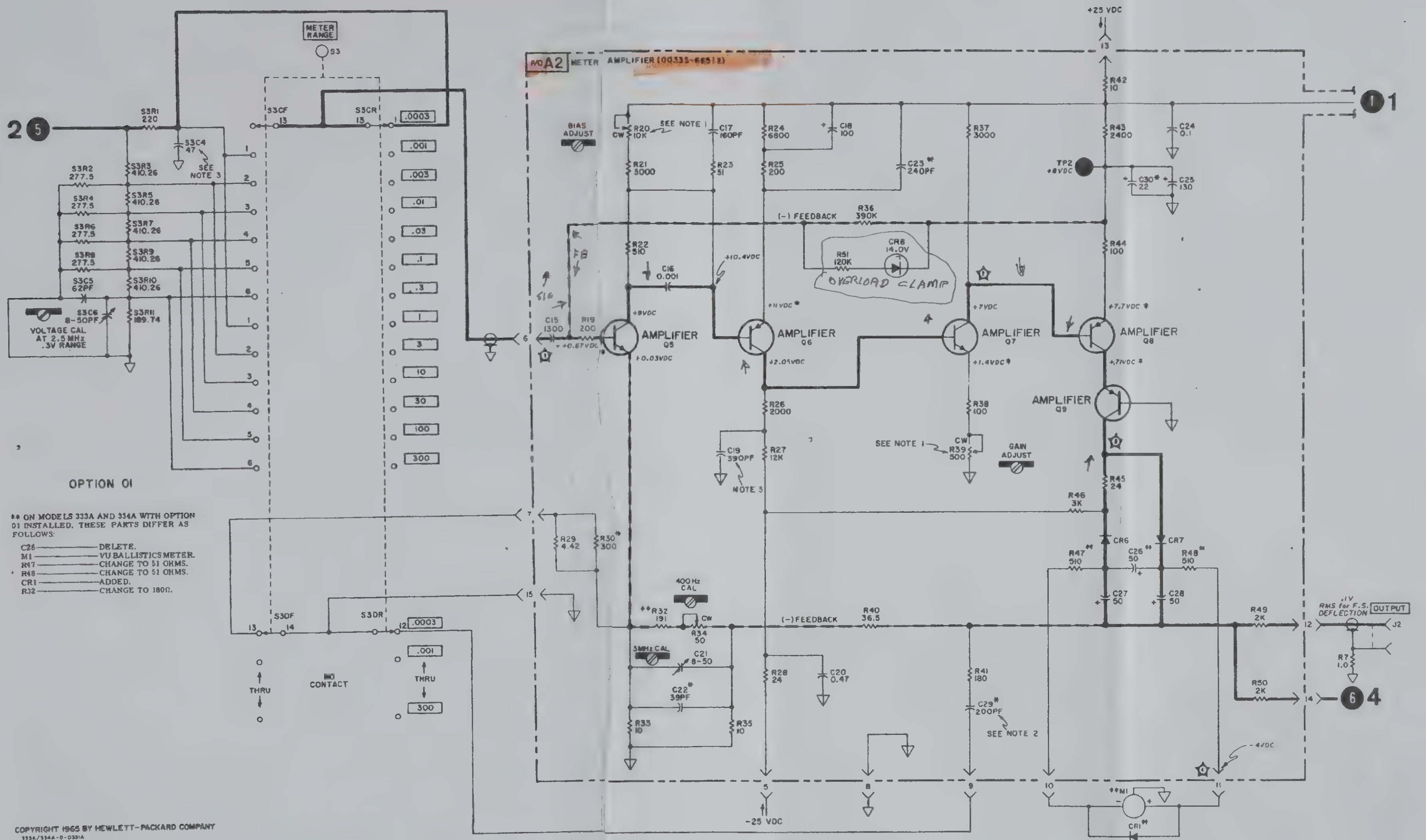
2

Figure 7-3. Rejection Amplifier (A3), Bridge Balance (P/O A6) and High Pass Filter (A7).

POST ATTENUATOR



** ON MODELS 333A AND 334A WITH OPTION 01 INSTALLED. THESE PARTS DIFFER AS FOLLOWS:

C26 —— DELETE.
M1 —— VU BALLISTICS METER.
R47 —— CHANGE TO 51 OHMS.
R48 —— CHANGE TO 51 OHMS.
CR1 —— ADDED.
R32 —— CHANGE TO 180Ω.

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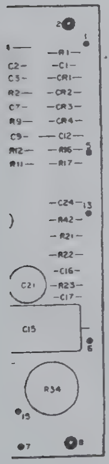
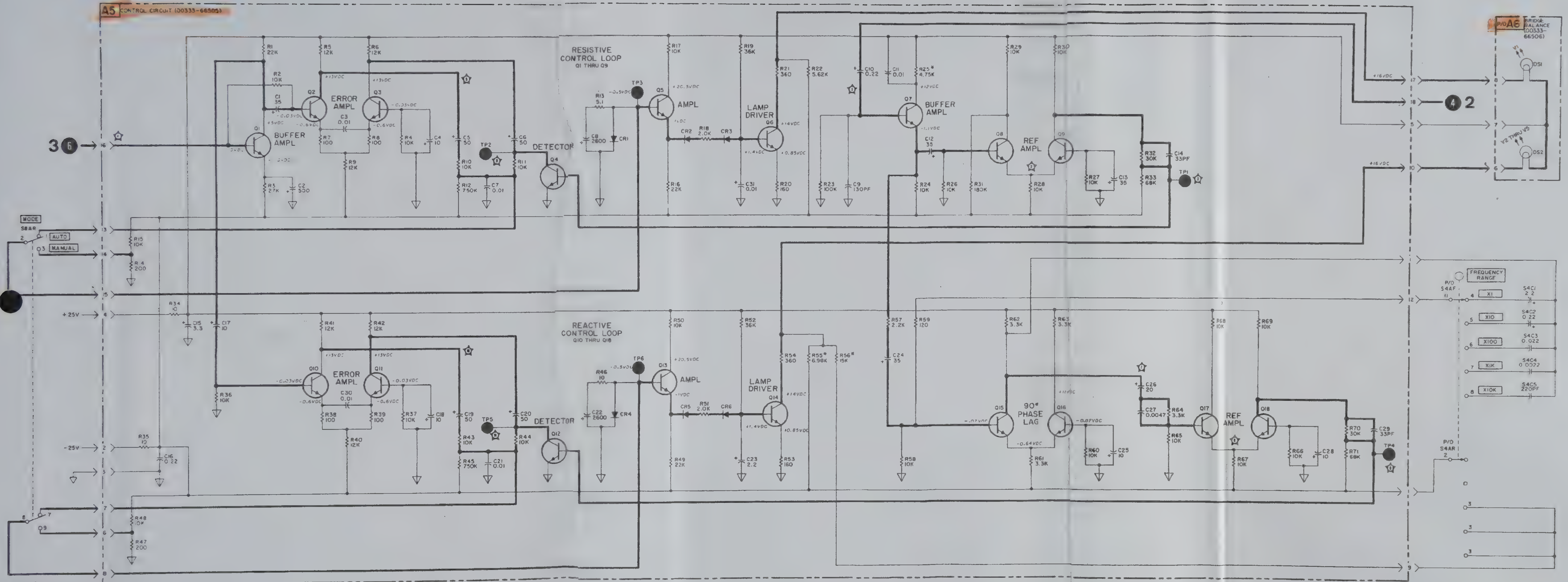
333A/334A-0-0331A



5512

3

Figure 7-4. Meter Amplifier (P/O A2)



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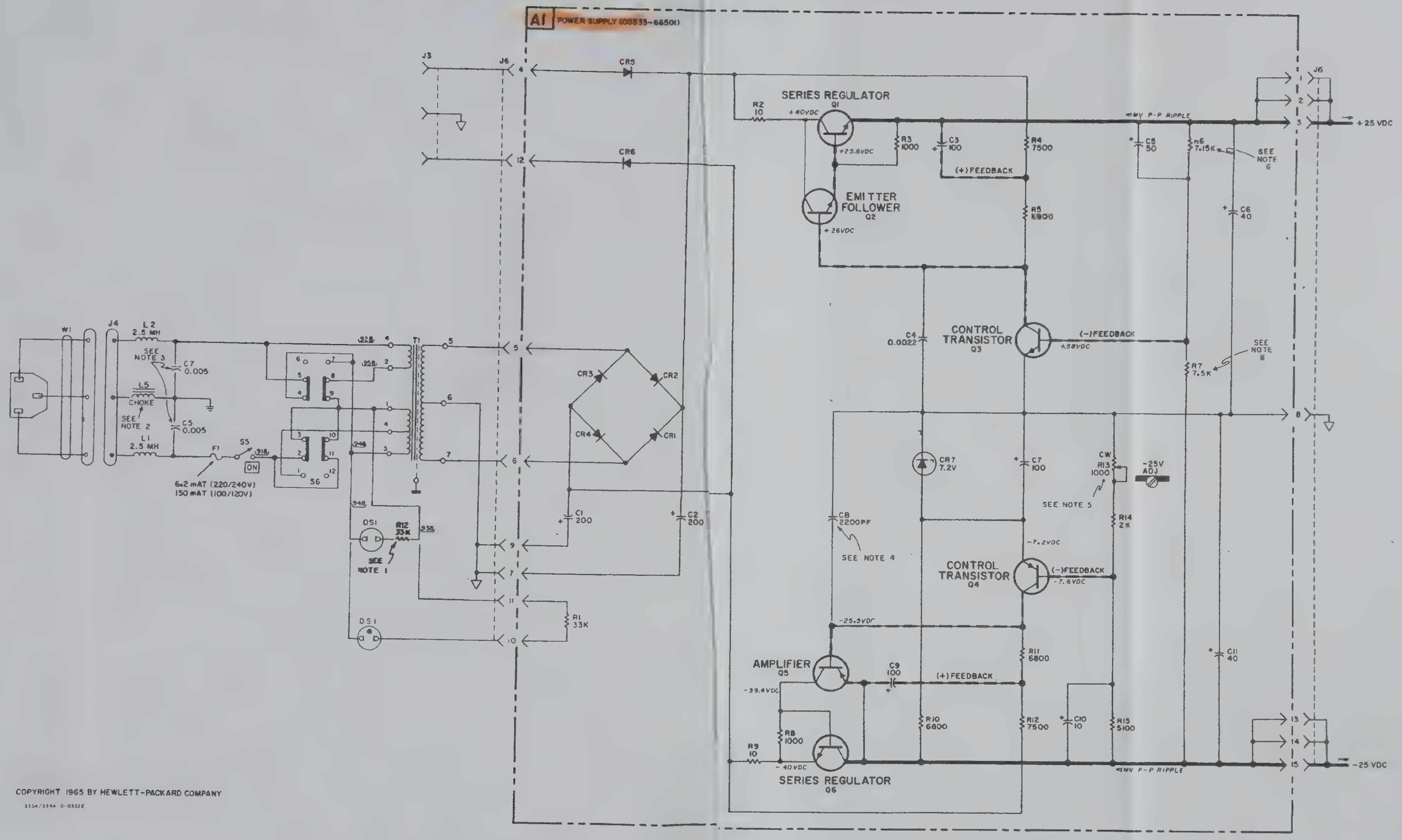
4

Figure 7-5. Control Circuit (A5) and Bridge Balance (P/O A6)



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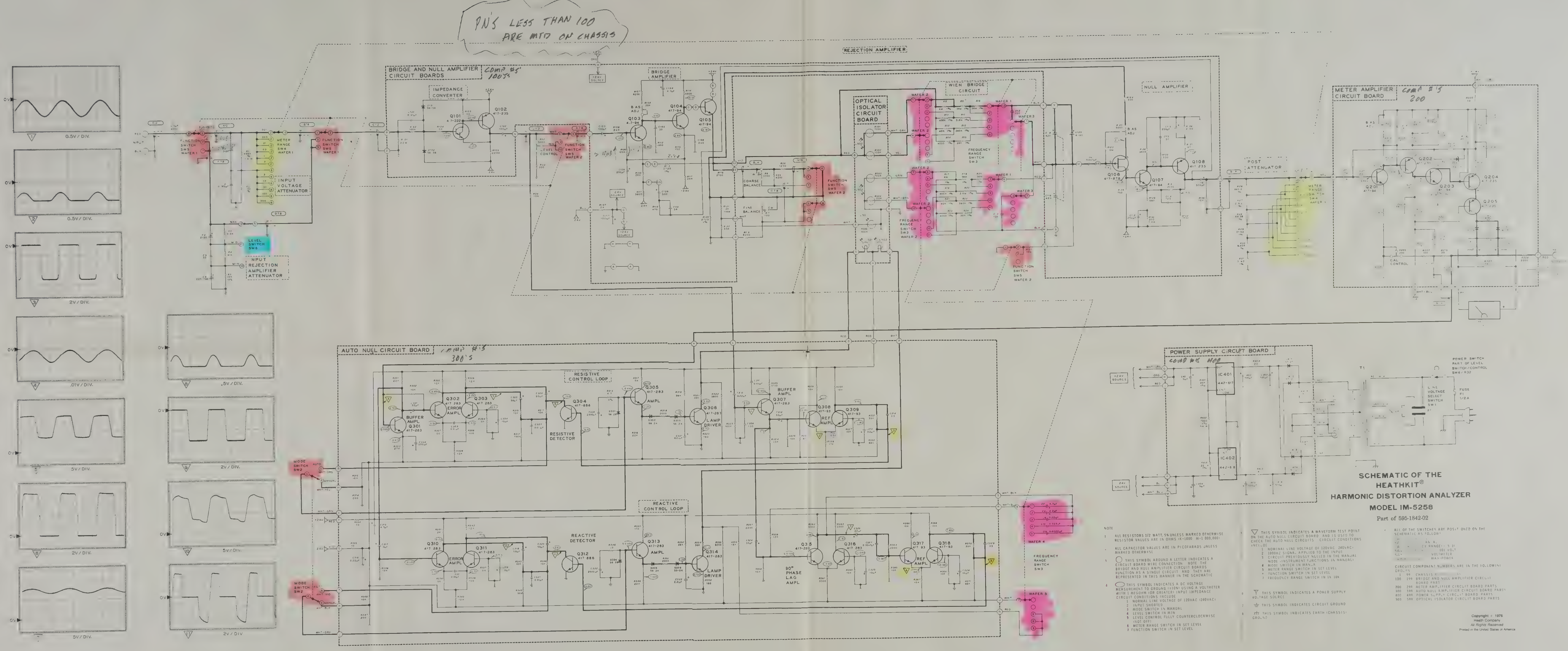
333A/334A D-0332E

Figure 7-6. Power Supply (A1)

1.25 / 1.2x10^5 ≅ 1x10^-5 =10µA

PN'S LESS THAN 100
ARE MTD ON CHASSIS



SCHEMATIC OF THE HEATHKIT® HARMONIC DISTORTION ANALYZER MODEL IM-5258

Part of 595-1842-02

NOTE

1. ALL RESISTORS 1/2 WATT, 5% UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (K=1000 M=1,000,000).

2. ALL CAPACITOR VALUES ARE IN PICOFARADS UNLESS MARKED OTHERWISE.

3. ◯ THIS SYMBOL AROUND A LETTER INDICATES A CIRCUIT BOARD WIRE CONNECTION. NOTE: THE BRIDGE AND NULL AMPLIFIER CIRCUIT BOARDS FUNCTION AS A SINGLE CIRCUIT, AND THEY ARE REPRESENTED IN THIS MANNER IN THE SCHEMATIC.

4. ⬭ THIS SYMBOL INDICATES A DC VOLTAGE MEASUREMENT TO GROUND (±10%) USING A VOLTMETER WITH 1 MEGOHM (OR GREATER) INPUT IMPEDANCE. CIRCUIT CONDITIONS INCLUDE:
   1. NORMAL LINE VOLTAGE OF 120VAC (240VAC)
   2. INPUT SHORTED
   3. MODE SWITCH IN MANUAL
   4. LEVEL SWITCH IN MIN
   5. LEVEL CONTROL FULLY COUNTERCLOCKWISE (NOT OFF)
   6. METER RANGE SWITCH IN SET LEVEL
   7. FUNCTION SWITCH IN SET LEVEL

5. ▽ THIS SYMBOL INDICATES A WAVEFORM TEST POINT ON THE AUTO NULL CIRCUIT BOARD, AND IS USED TO CHECK THE AUTO NULL CIRCUITS. CIRCUIT CONDITIONS INCLUDE:
   1. NOMINAL LINE VOLTAGE OF 120VAC (240VAC)
   2. 1000HZ SIGNAL APPLIED TO THE INPUT
   3. CIRCUIT PREVIOUSLY NULLED IN THE MANUAL MODE (INSTRUMENT FUNCTIONS IN MANUAL)
   4. MODE SWITCH IN MANUAL
   5. METER RANGE SWITCH IN SET LEVEL
   6. FUNCTION SWITCH IN SET LEVEL
   7. FREQUENCY RANGE SWITCH IN 1k-10k

6. Y THIS SYMBOL INDICATES A POWER SUPPLY VOLTAGE SOURCE.

7. ⏚ THIS SYMBOL INDICATES CIRCUIT GROUND.

8. ⏚ THIS SYMBOL INDICATES EARTH (CHASSIS) GROUND.

9. ALL OF THE SWITCHES ARE POSITIONED ON THE SCHEMATIC AS FOLLOWS:
   [illegible] AN A.
   [illegible] CY RANGE [illegible]
   [illegible] 001 VOLT
   [illegible] VOLTMETER
   [illegible] MAX/POWER

10. CIRCUIT COMPONENT NUMBERS ARE IN THE FOLLOWING GROUPS:

1	99	CHASSIS [illegible]
100	199	BRIDGE AND NULL AMPLIFIER CIRCUIT BOARD PART
200	299	METER AMPLIFIER CIRCUIT BOARD PARTS
300	399	AUTO NULL AMPLIFIER CIRCUIT BOARD PARTS
400	499	POWER SUPPLY CIRCUIT BOARD PARTS
500	599	OPTICAL ISOLATOR CIRCUIT BOARD PARTS

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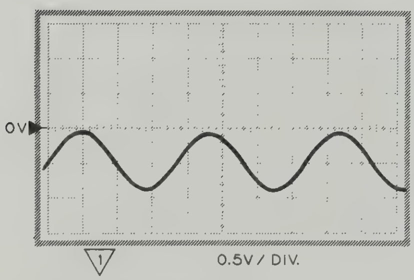
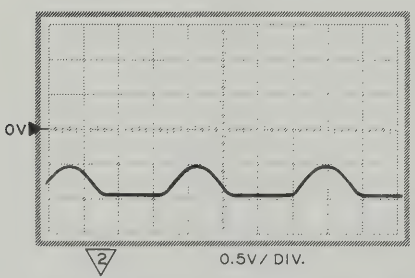
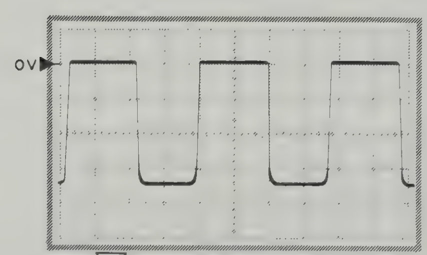


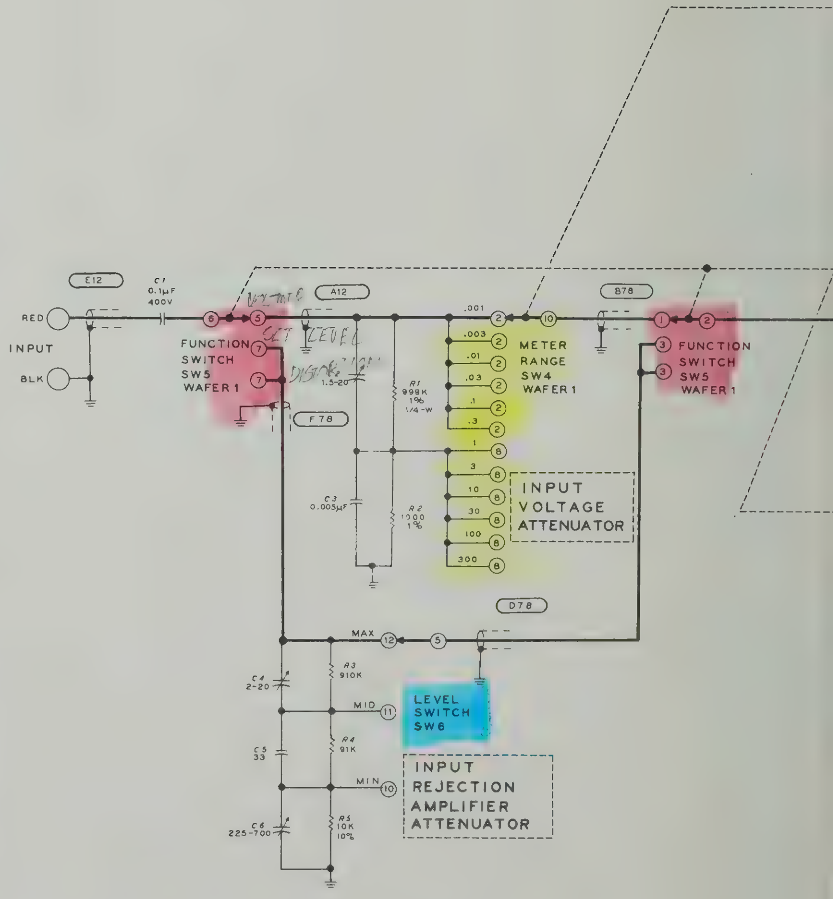
1 0.5V / DIV.

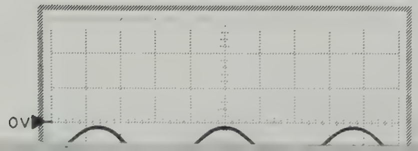


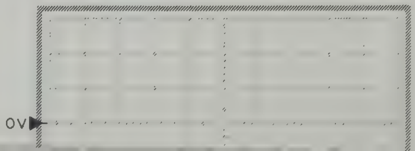
2 0.5V / DIV.



3 2V / DIV.







AUTO N

6/14/16

HEATHKIT HARM DIST MTR

1) ROT SWITCHES FROZEN BY DRIED OUT LUBE AT KNOB END.

   A) SWITCHES OK. - FREQ, MODE, LEVEL
   B) ✓ STUCK - FUNCTION
   C) ✓ REPAIRED - METER REPAIRED
   THIS SW WAS DISASSEMBLED, CLEANED & REASSEMBLED.

   NOTE - SEEMS TO ME FREQ RANGE SW WAS STUCK, BUT NOW WORKS. THINK I RAN SOME WD40 DOWN SHAFT & LET IT SIT A WEEK WITH SHAFT POINTING UP

   6/14 → I PUT WD40 DOWN SHAFT OF FUNCTION SWITCH - SEE WHAT IT'S LIKE IN A FEW DAYS.

2) HAVE GONE THRU FIRST FEW PAGES (THRU 18 A) OF ASSY MANUAL & CHECKED THAT PARTS ARE INSTALLED PROPERLY. MARKED STEPS CHECKED WITH A "B".
3) WD40 DID NOT WORK - DISASSEMBLED FUNCTION SWITCH & LUBED.
4) RE ASSEMBLED FUNCTION & MTR RANGE SWITCHES
5) STARTED INITIAL TESTS PG 62. COULD NOT GET MTR AMP Q3-C TO BE 7V, NO MATTER WHAT POSITION BIAS WAS SET. FOUND ZD201 TO BE FAULTY, WHEN DISCONNECTED MTR AMP Q3-C CAN BE SET TO 7V (AS RQD IN TEST PROC)
6) TRACING VOLTMETER FROM INPUT USING 500 MV SINE WAVE @ INPUT TERMS. GETS THRU INPUT STAGE OK, BUT DOES DO NOT MAKE IT PAST BRIDGE AMP. GOES THRU Q103 THEN ?, [illegible]!

Heathkit® Manual

for the

HARMONIC DISTORTION ANALYZER

Model IM-5258

595-1842-02

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HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

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UNPACKING INSTRUCTIONS

DO NOT UNPACK YOUR HARMONIC DISTORTION ANALYZER PARTS UNTIL YOU ARE INSTRUCTED TO DO SO.

The Harmonic Distortion Analyzer packaging consists of the main carton which contains a small carton marked Packs 1-6, and a number of loose parts, some of which are wrapped. These loose parts will be considered the Final Pack even though they may not be marked as such. NEVER UNPACK MORE THAN ONE PACK AT A TIME.

The carton marked Packs 1-6 contains a "Pack Index Sheet," and the parts for the circuit boards. The "Pack Index Sheet" identifies the location of each pack in the carton. Do not unpack the entire carton at one time. Refer to the "Pack Index Sheet" when the Manual instructs you to locate a certain pack. You will also use some parts from the Final Pack to assemble each circuit board.

Return any part, or group of parts, that is packaged in a bag or envelope with a part number to its container after you identify it and leave it there until you actually use it in a step. This will prevent intermixing of parts and aid in part identification.

PARTS LIST

The following pages contain several parts lists, one for each major section of this kit (Chassis, Power Supply Circuit Board, etc.). Check the parts and assemble this kit in the following manner:

1. Remove the carton marked "Packs 1-6" and open it.
2. Refer to the "Pack Index Sheet" inside the carton and check the Pack #1 parts against the "Power Supply Circuit Board" parts list. (The parts lists have "key numbers." These correspond to parts drawings in the "Illustration Booklet.")
3. Remove the indicated parts from the Final Pack.
4. Proceed to "Step-by-Step Assembly" and study the "Assembly Notes". Then complete the power supply circuit board.
5. After you complete the power supply circuit board assembly, return, as directed, to the next parts list.
6. Repeat the process for each parts list and assembly section.

Any part that is packaged in an individual envelope with a part number on it should be placed back in the envelope after you identify it until it is called for in a step. Do not throw away any package material until all the parts are accounted for.

Each circuit part in this kit has its own component number (R2, C4, etc.). Use these numbers when you want to positively identify the same part in the various sections of the Manual. These numbers, which are especially useful if a part has to be replaced, appear:

- In the Parts List,
- At the beginning of each step where a component is installed,
- In some illustrations,
- In the Schematic,
- In the sections at the rear of the Manual.

To order a replacement part, always include the Part Number and use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, use one of the "Expedited Parts Order Forms" at the rear of this Manual, or refer to "Replacement Parts" inside the rear cover. Your Warranty is inside the front cover. For pricing information, refer to the separate "Heath Parts Price List."

POWER SUPPLY CIRCUIT BOARD

Refer to the "Pack Index Sheet" inside the carton marked Packs 1-6 and unpack Pack #1.

RESISTORS

NOTE: 5% resistors have a gold fourth color band, 10% resistors have a silver fourth color band, and precision resistors are not color coded.

1/2-Watt, 5%

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	1-155	1	24 Ω (red-yellow-black)	R404
A1	1-145	1	47 Ω (yellow-violet-black)	R405
A1	1-111	2	150 Ω (brown-green-brown)	R406, 407

Precision, 1%

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A2	2-89-12	1	7320 Ω (7.320 k), 1/4-watt	R402
A2	2-38	1	20 kΩ	R401
A2	2-188	1	22.5 kΩ	R403

CAPACITORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B3	25-801	2	1.5 μF electrolytic	C401, 404
B4	25-234	4	500 μF electrolytic	C402, 403, 405, 406

DIODES - INTEGRATED CIRCUITS

NOTE: Diodes, transistors, and integrated circuits are marked for identification in one of the following four ways:

1. Part number
2. Type number. (On integrated circuits, this refers only to the numbers; the letters may be different or missing.)

Diodes - Integrated Circuits (cont'd.)

3. Part number and type number.
4. Part number with a type number other than the one shown.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
C1	57-27	4	1N2071 diode	D401, 402, 403, 404
E1	442-617	1	UA78MGT2C +24-volt regulator	IC401
E1	442-618	1	UA79MGT2C −24-volt regulator	IC402

HARDWARE (Shown actual size.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION
J1	250-213	4	4-40 × 5/16″ screw
J8	252-15	4	4-40 nut
J19	254-41	4	#4 lockwasher

MISCELLANEOUS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION
K9	490-5	1	Nut starter

PARTS FROM FINAL PACK

HEATH Part No.	QTY.	DESCRIPTION
85-1706-1	1	Power supply circuit board
597-260	1	Parts Order Form
		Assembly Manual (See Page 1 for part number.)
		Solder

Proceed to Page 13 and study the "Assembly Notes." Then proceed to Page 15 and assemble the power supply circuit board. Do not unpack the other packs until you are instructed to do so.

METER AMPLIFIER CIRCUIT BOARD

Refer to the "Pack Index Sheet" inside the carton marked Packs 1-6 and unpack Pack #2 when you are instructed to do so in a step.

RESISTORS

NOTE: The resistors may be packed in more than one envelope. Open all the resistor envelopes in this pack before you check the resistors against the Parts List.

1/2-Watt, 5%

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	1-173	3	10 Ω (brown-black-black)	R206, 214, 220
A1	1-155	1	24 Ω (red-yellow-black)	R213
A1	1-156	1	39 Ω (orange-white-black)	R215
A1	1-62	1	51 Ω (green-brown-black)	R208
A1	1-123	2	100 Ω (brown-black-brown)	R207, 222
A1	1-137	2	200 Ω (red-black-brown)	R201, 210
A1	1-147	1	220 Ω (red-red-brown)	R219
A1	1-5	1	360 Ω (orange-blue-brown)	R227
A1	1-63	3	510 Ω (green-brown-brown)	R204, 224, 225
A1	1-90	3	2000 Ω (red-black-red)	R211, 226, 228
A1	1-89	1	2400 Ω (red-yellow-red)	R221
A1	1-150	3	3000 Ω (orange-black-red)	R203, 218, 223
A1	1-51	1	6800 Ω (blue-gray-red)	R209
A1	1-109	1	12 kΩ (brown-red-orange)	R212
A1	1-167	1	120 kΩ (brown-red-yellow)	R217
A1	1-77	1	390 kΩ (orange-white-yellow)	R216

Controls

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A4	10-917	1	200 Ω	R205
A4	10-390	1	20 kΩ	R202

CAPACITORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B1	20-178	1	160 pF mica	C204
B1	20-125	1	240 pF mica	C207
B1	20-106	1	390 pF mica	C203
B2	21-163	1	0.001 μF (1000 pF) ceramic	C202
B2	21-195	1	0.1 μF ceramic	C208

NOTE: Tantalum and Mylar* capacitors can be marked four different ways. EXAMPLE: 0.47, 0.47 k, 0.47 M, or 0.47 μF. However, the Parts List and installation instructions will always use μF.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B5	25-256	1	0.47 μF tantalum	C206
B4	25-825	3	50 μF electrolytic	C210, 211, 212
B4	25-117	2	100 μF electrolytic	C205, 209
B4	25-148	1	1000 μF electrolytic	C201

DIODES - TRANSISTORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
C1	56-25	1	1N4166A 14-volt zener diode	ZD201
C1	56-26	2	1N191 (brown-white-brown) diode	D202, 203
D1	417-94	2	2N3416 transistor	Q201, 203
D1	417-235	3	2N4121 transistor	Q202, 204, 205

PART FROM FINAL PACK

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
	85-1704-1	1	Meter amplifier circuit board	

Proceed to Page 20 and assemble the meter amplifier circuit board. Do not unpack the other packs until you are instructed to do so.

*DuPont Registered Trademark

BRIDGE AMPLIFIER CIRCUIT BOARD

Unpack Pack #3 when you are directed to do so in a step.

RESISTORS

1/2-Watt, 5% (unless otherwise specified.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	1-155	1	24 Ω (red-yellow-black)	R137
A1	1-123	1	100 Ω (brown-black-brown)	R103
A1	1-111	1	150 Ω (brown-green-brown)	R115
A1	1-137	1	200 Ω (red-black-brown)	R110
A1	1-56	1	240 Ω (red-yellow-brown)	R106
A1	1-172	1	1000 Ω (brown-black-red)	R112
A1	1-57	1	2200 Ω (red-red-red)	R105
A1	1-82	1	3600 Ω (orange-blue-red)	R111
A1	1-51	1	6800 Ω (blue-gray-red)	R114
A1	1-114	1	8200 Ω (gray-red-red)	R107
A1	1-105	1	10 kΩ (brown-black-orange)	R104
A1	1-132	1	20 kΩ (red-black-orange)	R117
A1	1-104	1	100 kΩ (brown-black-yellow)	R102
A1	1-167	1	120 kΩ (brown-red-yellow)	R109
A1	1-70	1	22 MΩ, 10% (red-red-blue)	R101

Control

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A4	10-390	1	20 kΩ	R108

CAPACITORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B1	20-100	1	30 pF mica	C105
B1	20-185	1	240 pF mica	C108
B2	21-16	1	0.01 μF ceramic	C101
B6	25-276	1	4.7 μF tantalum	C104
B4	25-248	3	100 μF electrolytic	C102, 103, 107
B3	25-104	1	200 μF electrolytic	C106
B10	31-52	1	8-60 pF trimmer	C120

DIODES-TRANSISTORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
C1	56-56	2	IN4149 diode	D101, 102
D1	417-94	2	2N3416 transistor	Q103, 104
D1	417-222	1	Selected transistor	Q101
D1	417-235	1	2N4121 transistor	Q102

PART FROM FINAL PACK

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
	85-1703-1	1	Bridge amplifier circuit board	

Proceed to Page 23 and assemble the bridge amplifier circuit board. Do **not** unpack the other packs until you are instructed to do so.

NULL AMPLIFIER CIRCUIT BOARD

Unpack Pack #4 when you are directed to do so in a step.

RESISTORS

1/2-Watt, 5% (unless otherwise specified.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	1-145	1	47 Ω (yellow-violet-black)	R135
A1	1-121-12	1	300 Ω, 1/4-watt (orange-black-brown)	R130
A1	1-151	1	330 Ω (orange-orange-brown)	R133
A1	1-157	1	470 Ω (yellow-violet-brown)	R118
A1	1-95	1	560 Ω (green-blue-brown)	R129
A1	1-81	1	1500 Ω (brown-green-red)	R124
A1	1-90	2	2000 Ω (red-black-red)	R131, 134
A1	1-158	1	2700 Ω (red-violet-red)	R116
A1	1-82	1	3600 Ω (orange-blue-red)	R128
A1	1-164	2	7500 Ω (violet-green-red)	R126, 132
A1	1-105	1	10 kΩ (brown-black-orange)	R136
A1	1-76	1	33 kΩ (orange-orange-orange)	R122
A1	1-166	1	10 MΩ (brown-black-blue)	R123

1% Precision

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A2	2-67	2	2725 Ω (2.725 k), 1/2-watt	R113, 120
A2	2-90-12	1	13 kΩ, 1/4-watt	R121

Control

A4	10-904	1	5000 Ω (5 k)	R125

CAPACITORS

B1	20-78	1	56 pF mica	C110
B1	20-177	1	125 pF mica	C114
B1	20-103	1	150 pF mica	C113
B4	25-160	2	250 μF electrolytic	C112, 115
B3	25-199	2	500 μF electrolytic	C109, 116

TRANSISTORS

D1	417-94	2	2N3416	Q105, 107
D1	417-235	1	2N4121	Q108
D3	417-878	1	Selected FET	Q106

PART FROM FINAL PACK

	85-1780-1	1	Null amplifier circuit board	

Proceed to Page 25 and assemble the null amplifier circuit board. Do not unpack the remaining packs until you are instructed to do so.

AUTO NULL AMPLIFIER CIRCUIT BOARD

Unpack Pack #5 when you are instructed to do so in a step.

RESISTORS

1/2-Watt, 5% (unless otherwise specified.)

The resistors may be packed in more than one envelope. Open all the resistor envelopes in this pack before you check them against the Parts List.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	1-129	1	4.7 Ω, 10% (yellow-violet-gold)	R313
A1	1-173	3	10 Ω (brown-black-black)	R334, 335, 346
A1	1-123	4	100 Ω (brown-black-brown)	R307, 308, 338, 339
A1	1-175	1	120 Ω (brown-red-brown)	R359
A1	1-136	2	160 Ω (brown-blue-brown)	R320, 353
A1	1-137	2	200 Ω (red-black-brown)	R314, 347
A1	1-5	2	360 Ω (orange-blue-brown)	R321, 354
A1	1-90	2	2000 Ω (red-black-red)	R318, 351
A1	1-57	1	2200 Ω (red-red-red)	R357
A1	1-122	4	3300 Ω (orange-orange-red)	R361, 362, 363, 364
A1	1-64	1	5100 Ω (green-brown-red)	R325
A1	1-113	1	5600 Ω (green-blue-red)	R322
A1	1-114	1	8200 Ω (gray-red-red)	R355
A1	1-105	25	10 kΩ (brown-black-orange)	R302, 304, 310, 311, 315, 317, 324, 326, 327, 328, 329, 330, 336, 337, 343, 344, 348, 350, 358, 360, 365, 366, 367, 368, 369
A1	1-109	6	12 kΩ (brown-red-orange)	R305, 306, 309, 340, 341, 342
A1	1-162	1	18 kΩ (brown-gray-orange)	R356
A1	1-58	3	22 kΩ (red-red-orange)	R301, 316, 349
A1	1-124	1	27 kΩ (red-violet-orange)	R303
A1	1-191	2	30 kΩ (orange-black-orange)	R332, 370
A1	1-88	2	36 kΩ (orange-blue-orange)	R319, 352
A1	1-50	2	68 kΩ (blue-gray-orange)	R333, 371
A1	1-104	1	100 kΩ (brown-black-yellow)	R323
A1	1-185	1	180 kΩ (brown-gray-yellow)	R331
A1	1-192	2	750 kΩ (violet-green-yellow)	R312, 345

CAPACITORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B1	20-160	2	33 pF mica	C314, 329
B1	20-104	1	130 pF mica	C309
B2	21-16	5	0.01 μF ceramic	C303, 307, 311, 321, 330
B8	27-104	1	0.0047 μF (4700 pF) Mylar	C327
B8	27-44	1	0.01 μF Mylar	C331
B5	25-255	2	0.22 μF tantalum	C310, 316
B6	25-221	1	2.2 μF tantalum	C323
B6	25-276	1	4.7 μF tantalum	C315
B4	25-115	5	10 μF electrolytic	C304, 317, 318, 325, 328
B4	25-233	1	22 μF electrolytic	C326
B7	25-211	4	33 μF tantalum	C301, 312, 313, 324
B4	25-825	4	50 μF electrolytic	C305, 306, 319, 320
B4	25-824	1	500 μF electrolytic	C302
B4	25-823	2	2500 μF electrolytic	C308, 322

DIODES - TRANSISTORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
C1	56-24	4	1N458 diode	D302, 303, 305, 306
C1	56-26	2	1N191 (brown-white-brown) diode	D301, 304
D4	417-93	4	2N3646 transistor	Q308, 309, 317, 318
D1	417-283	12	Selected transistor	Q301, 302, 303, 305, 306, 307, 310, 311, 313, 314, 315, 316
D5	417-886	2	2N2432 transistor	Q304, 312

PARTS FROM FINAL PACK

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
	85-1705-1	1	Auto null amplifier circuit board	
	134-965	1	Wire harness	
	343-15	78″	Coaxial cable (50 Ω)	
	344-50	60″	Black wire	
	344-52	60″	Red wire	
	344-59	60″	White wire	
	346-1	6″	Black sleeving	

NOTE: Most of the wire will not be used until you assemble the chassis.

Proceed to Page 27 and assemble the auto null amplifier circuit board. Do not unpack the other packs until you are instructed to do so.

OPTICAL ISOLATOR CIRCUIT BOARD

Unpack Pack #6 when you are instructed to do so in a step.

RESISTORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A5	9-70	3	100 kΩ photosensitive	R502, 504, 505
A5	9-71	2	700 kΩ photosensitive	R501, 503

MISCELLANEOUS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
F1	95-627	2	Housing assembly (top and bottom)	

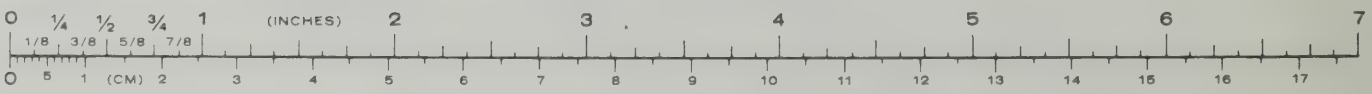
Miscellaneous (cont'd.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
J2	250-186	4	#4 × 3/8" self-tapping screw	
F2	412-619	2	Incandescent lamp (1869D)	L501, 502
J14	253-43	4	#5 fiber washer	

PART FROM FINAL PACK

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
	85-1709-1	1	Optical isolator circuit board	

Proceed to Page 32 and assemble the optical isolator circuit board. Do not unpack the other packs until you are instructed to do so.



CHASSIS

Unpack the rest of the kit when you are instructed to do so in a step.

RESISTORS

1/2-Watt, 5%

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	1-123	1	100 Ω (brown-black-brown)	R127
A1	1-151	1	330 Ω (orange-orange-brown)	R33
A1	1-80	1	1200 Ω (brown-red-red)	R36
A1	1-116	1	6200 Ω (blue-red-red)	R35
A1	1-114	1	8200 Ω (gray-red-red)	R119
A1	1-105	2	10 kΩ (brown-black-orange)	R5, 34
A1	1-127	1	91 kΩ (white-brown-orange)	R4
A1	1-176	1	910 kΩ (white-brown-yellow)	R3

1/2-Watt, 1% Precision (unless otherwise specified.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A2	2-348	1	3.162 Ω	R31
A2	2-223	1	6.838 Ω	R30
A2	2-219	1	21.62 Ω	R29
A2	2-23	1	68.38 Ω	R28
A2	2-25	1	216.2 Ω	R27
A2	2-28	1	683.8 Ω	R26
A2	2-58	1	1000 Ω (1 k)	R2
A2	2-113	2	4000 Ω (4 k)	R14, 23
A2	2-120	2	36 kΩ	R15, 24
A2	2-202	2	40 kΩ	R12, 21
A2	2-119	2	360 kΩ	R13, 22
A2	2-138	2	400 kΩ	R10, 19
A2	2-45-11	1	999 kΩ, 1/4-watt	R1
A2	2-118	2	3.6 MΩ	R11, 20
A2	2-301	2	4 MΩ	R8, 17
A3	2-347	4	36 MΩ	R9, 16, 18, 25

Control

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A6	12-158	1	3000 Ω/100 Ω dual concentric	R6/R7

CAPACITORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B1	20-160	1	33 pF mica	C5
B1	20-149	2	150 pF mica	C12, 13
B7	25-195	1	2.2 μF tantalum	C8
B6	25-276	1	4.7 μF tantalum	C7
B12	26-9	1	420 pF-420 pF variable, 2-section	C118, 119
B9	27-70	1	0.0022 μF (2200 pF) Mylar	C11
B8	27-115	1	0.005 μF (5000 pF) Mylar	C3
B9	27-63	1	0.022 μF Mylar	C10
B8	27-43	1	0.047 μF Mylar	C111
B8	27-28	1	0.1 μF Mylar	C1
B9	27-85	1	0.22 μF Mylar	C9
B10	31-56	1	1.5-20 pF trimmer	C2
B11	31-70	1	40/20/700 pF 3-section trimmer	C4, 6

SWITCHES

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
G1	60-54	1	120/240 slide switch	SW1
G2	62-41	1	Mode switch	SW2
G3	63-1258	1	Frequency range switch	SW3
G4	63-1259	1	Level switch/5000 Ω control	SW6/R32
G5	63-1260	1	Function switch	SW5
G6	63-1262	1	Meter range switch	SW4

METAL PARTS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
H1	200-1250	1	Chassis	
H2	203-1496-3	2	Side panel	
H3	203-1741-1	1	Front panel	
H4	203-1742-1	1	Rear panel	
H5	204-2142	1	Circuit board mounting bracket	
H6	204-2143	2	Meter mounting bracket	
H7	204-2145	1	Shield bracket	
H8	205-1599-1	2	Top/bottom panel	
H9	206-1228	1	Capacitor shield	
H10	206-1232	1	Switch shield	
H11	211-75	2	Handle	
H12	216-71	1	Top trim rail	
H13	216-72	1	Bottom trim rail	

HARDWARE (Shown actual size.)

NOTE: Hardware packets are marked to show the size of the hardware they contain (HDW #4, or, HDW #2 and #6, etc). You may have to open more than one packet — in this pack — to locate all the hardware of any one size (# 6, for example).

#4 Hardware

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
J1	250-213	26	4-40 × 5/16″ screw	
J3	250-419	4	#4 × 5/8″ self-tapping screw	
J8	252-2	26	4-40 nut	
J18	254-9	23	#4 lockwasher	
J22	259-9	4	#4 solder lug	

#6 Hardware

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
J4	250-138	3	6-32 × 3/16″ screw	
J5	250-276	35	6-32×3/8″ black flat head screw	
J6	250-381	18	6-32 × 3/8″ black screw	
J9	252-3	22	6-32 nut	
J11	252-84	20	6-32 push-on nut	
J13	253-27	6	#6 washer	
J15	254-1	17	#6 lockwasher	
J20	259-1	6	#6 solder lug	
J21	259-6	1	#6 solder terminal	

Miscellaneous Hardware

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
J7	250-15	1	8-32 × 1/8″ setscrew	
J10	252-7	5	Control nut	
J12	253-10	5	Control flat washer	
J16	254-4	1	Thick control lockwasher	
J17	254-5	3	Thin control lockwasher	

WIRE HARNESS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
	134-964	1	Power supply wire harness	
	134-966	1	Frequency range switch wire harness	

PLASTIC PARTS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
K1	73-45	5	Plastic grommet	
K2	75-17	4	Black binding post insulator	
K2	75-197	4	Red binding post insulator	
K3	75-736	1	Line cord strain relief	
K4	100-16-2	2	Black binding post cap	
K4	100-16-18	2	Red binding post cap	
K5	206-1109	1	Light shield	
K6	210-70	1	Meter bezel	
K7	261-34	4	Foot	
K8	456-37	1	Variable capacitor coupling	

KNOBS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
L1	462-97	1	Lever	
L2	462-361	1	Black concentric without wings	
L3	462-363	2	Red	
L4	462-1022	1	Black without wings	
L5	462-951	1	Black concentric with wings	
L6	462-973	1	Tuning	
L7	462-999	3	Black with wings	

MISCELLANEOUS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
	54-242	1	Power transformer	T1
	89-54	1	Line cord	
M1	100-863	1	Variable capacitor reduction drive	
M2	390-325	1	Number label	
M3	390-1247	1	Trim label	
M4	390-1255	1	Fuse label	
M5	391-34	1	Blue and white label	
M6	407-714	1	Meter	
M7	412-620	2	Lamp (1450)	PL1, 2
	421-20	1	1/2-ampere slow-blow fuse	F1
M8	422-1	1	Fuse block	
M9	427-3	4	Binding post base	
M10	431-38	1	3-lug terminal strip	
M11	434-171	2	Lamp socket	
M12	454-25	5	Cam nut	
M13	455-50	1	Tall large-hole knob bushing	
M14	455-51	2	Tall small-hole knob bushing	
M15	455-52	2	Short concentric knob bushing	
M16	455-619	3	Short D-hole knob bushing	

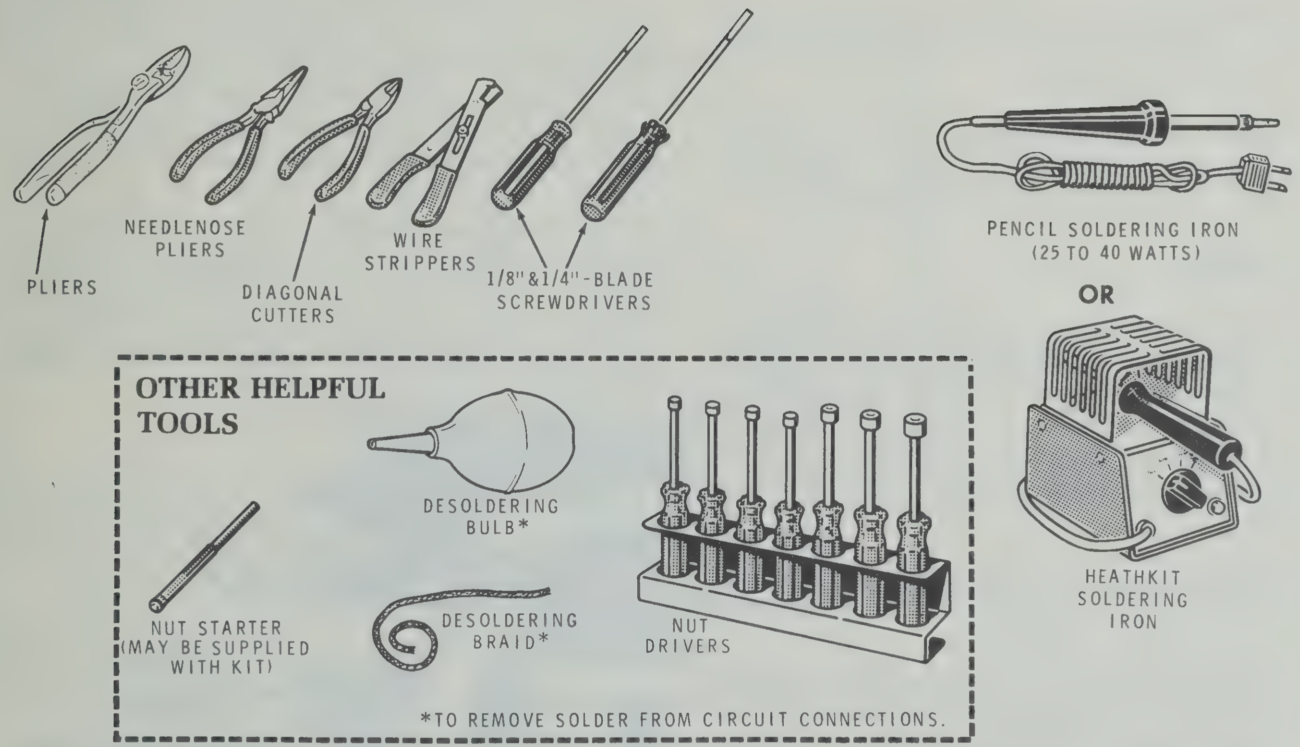
Proceed to Page 34 and complete the assembly of your kit.

STEP-BY-STEP ASSEMBLY

ASSEMBLY NOTES

TOOLS

You will need these tools to assemble your kit.


PLIERS
NEEDLENOSE PLIERS
DIAGONAL CUTTERS
WIRE STRIPPERS
1/8"&1/4"-BLADE SCREWDRIVERS
PENCIL SOLDERING IRON (25 TO 40 WATTS)
OR
HEATHKIT SOLDERING IRON
OTHER HELPFUL TOOLS
NUT STARTER (MAY BE SUPPLIED WITH KIT)
DESOLDERING BULB*
DESOLDERING BRAID*
NUT DRIVERS
*TO REMOVE SOLDER FROM CIRCUIT CONNECTIONS.

ASSEMBLY

1. Follow the instructions carefully, and read the entire step before you perform the operation.

2. The illustrations in the Manual are called Pictorials and Details. Pictorials show the overall operation for a group of assembly steps; Details generally illustrate a single step. When you are directed to refer to a certain Pictorial "for the following steps," continue using that Pictorial until you are referred to another Pictorial for another group of steps. Position all parts as shown in the Pictorials.

3. A separate "Illustration Booklet" contains illustrations (Pictorials, Details, etc.) that are too large for the Assembly Manual. When the Manual says to refer to a certain Pictorial or Detail, refer to the "Illustration Booklet" if that illustration is not on the same page or the page across from it.

   Keep the "Illustration Booklet" with the Assembly Manual. The illustrations in it are arranged in Pictorial number sequence.

4. Solder a part or a group of parts only when you are instructed to do so.

5. Resistors will be called out by their resistance value in Ω (ohms), kΩ (kilohms), or MΩ (megohms), and color code. Use 1/2-watt resistors unless directed otherwise.

6. Capacitors will be called out by their capacitance value (in pF or μF) and type (ceramic, Mylar, or electrolytic).

7. When you are instructed to cut something to a particular length, use the scales (rulers) provided at the bottom of the Manual pages.

SOLDERING

Soldering is one of the most important operations you will perform while assembling your kit. A good solder connection will form an electrical connection between two parts, such as a component lead and a circuit board foil. A bad solder connection could prevent an otherwise well-assembled kit from operating properly.

It is easy to make a good solder connection if you follow a few simple rules:

1. Use the right type of soldering iron. A 25 to 40-watt pencil soldering iron with a 1/8" or 3/16" chisel or pyramid tip works best.

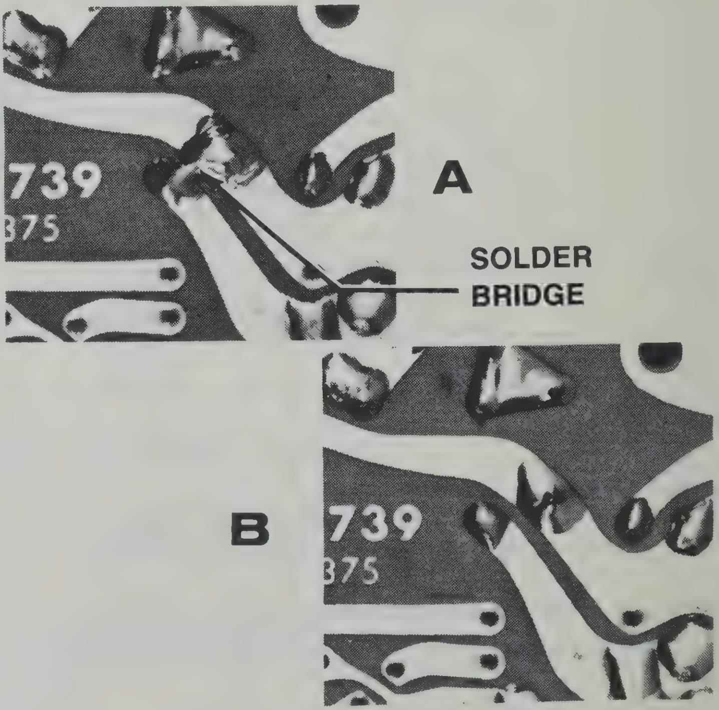
2. Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth; then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good connections. When solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and retinned.

3. Due to the small foil area around the circuit board holes and the small areas between foils, you must use the utmost care to prevent solder bridges between adjacent foil areas.

A solder bridge between two adjacent foils is shown in Part A of the photograph below. Part B shows how the connection should appear. A solder bridge may occur if you accidentally touch an adjacent previously soldered connection, if you use too much solder, of if you "drag" the soldering iron across other foils as you remove it from the connection. A good rule to follow is: Always take a good look at the foil area around each lead before you solder it. Then, when you solder the connection, make sure the solder remains in this area and does not bridge to another foil. This is especially important when the foils are small and close together.

Use only enough solder to make a good connection, and lift the soldering iron straight up from the circuit board. If a solder bridge should develop, turn the circuit board foil-side-down and heat the solder between connections. The excess solder will run onto the tip of the soldering iron, and this will remove the solder bridge. NOTE: The foil side of each circuit board has a coating on it called "solder resist." This is a protective insulation to help prevent solder bridges.

NOTE: Rosin core solder is supplied with your kit. This type of solder **must be used** for all soldering in the kit. If additional solder is needed, be sure to purchase rosin core (60:40 or 50:50 tin-lead content) radio-type solder. DO NOT use any other type solder or flux.



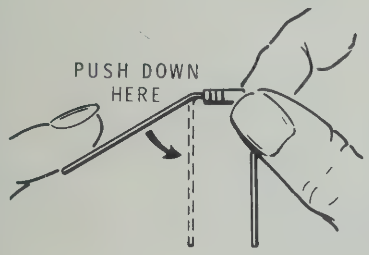
POWER SUPPLY CIRCUIT BOARD

START

(X) Position the power supply circuit board as shown with the printed side (not the foil side) up. Then complete the steps in the following Pictorials.

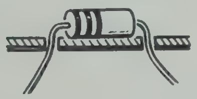
In the following steps you will be given detailed instructions on how to install and solder the first part on the circuit board. Read and perform each step carefully. Then use the same procedure whenever you install parts on a circuit board.

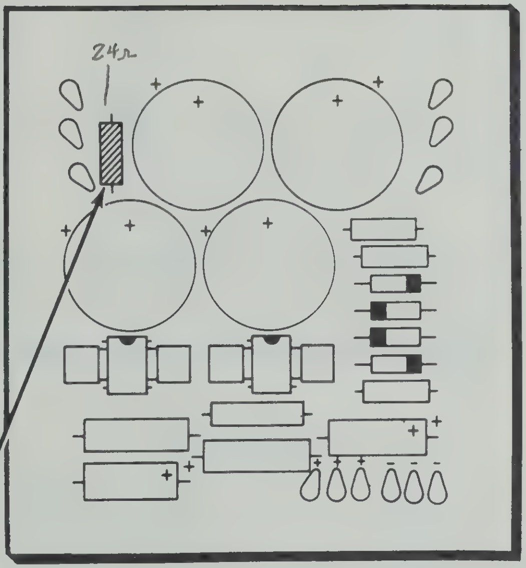
(X) R404: Hold a 24 Ω (red-yellow-black) resistor by the body as shown and bend the leads straight down.



(X) Push the leads through the holes at the proper location on the circuit board. The end with color bands may be positioned either way.

( ) Press the resistor against the circuit board. Then bend the leads outward slightly to hold the resistor in place.



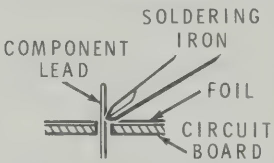


PICTORIAL 1-1

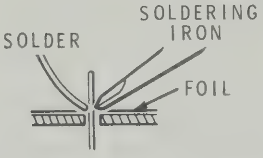
START

( ) Solder the resistor leads to the circuit board as follows:

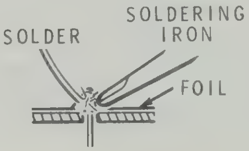
1. Push the soldering iron tip against both the lead and the circuit board foil. Heat **both** for 2 or 3 seconds.



2. Then apply solder to the other side of the connection. IMPORTANT: Let the heated lead and the circuit board foil melt the solder.

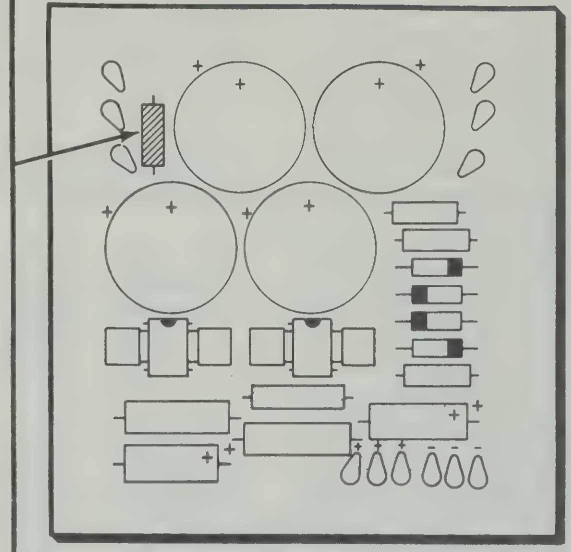


3. As the solder begins to melt, allow it to flow around the connection. Then remove the solder and the iron and let the connection cool.



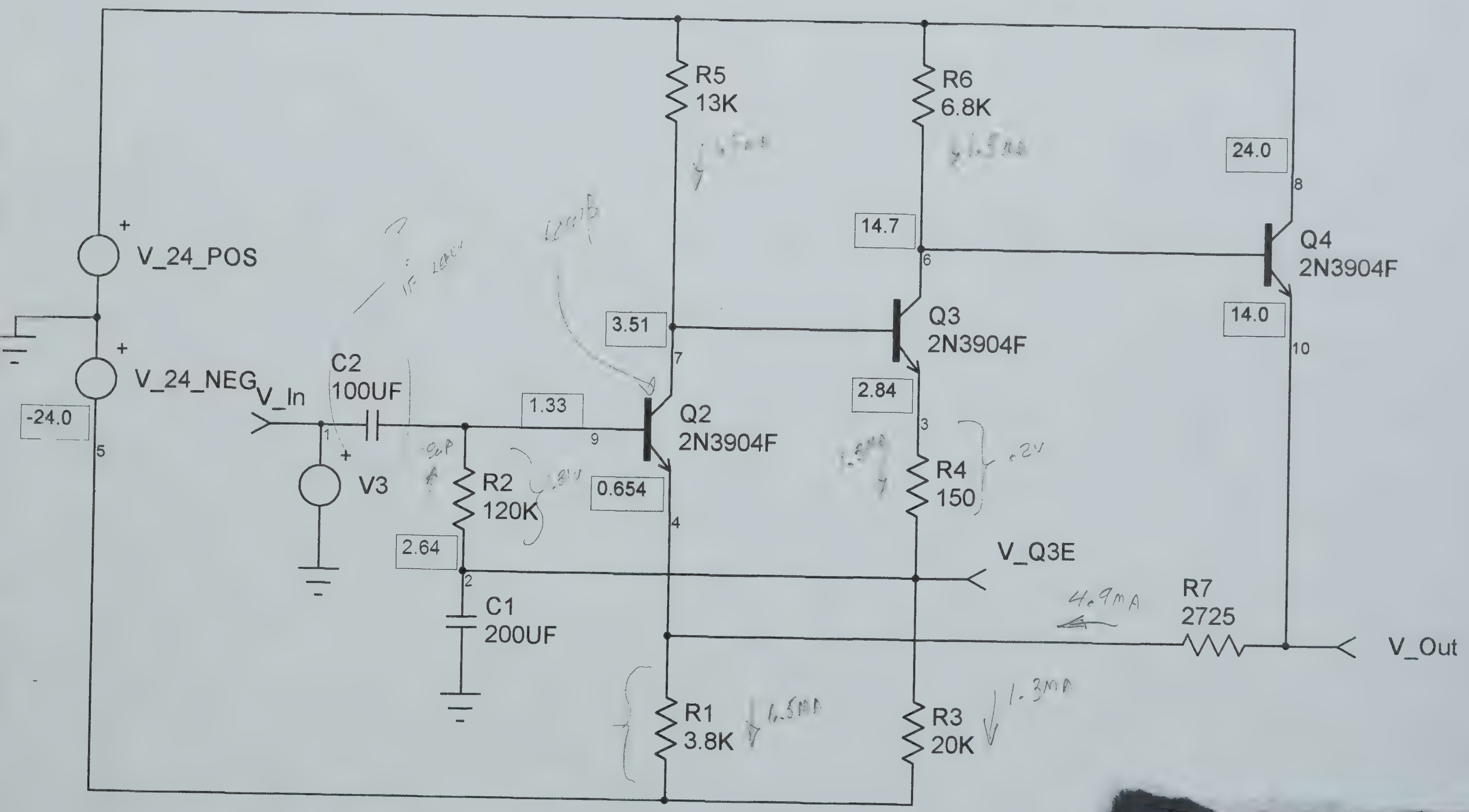
( ) Hold the lead with one hand while you cut off the excess lead length close to the connection. This will keep you from being hit in the eye by the flying lead.

( ) Check the connection. Compare it to the illustrations on the next page. After you have checked the solder connections, proceed with the assembly on Page 18. Use the same soldering procedure for each connection.



PICTORIAL 1-2

BRIDGE AMP

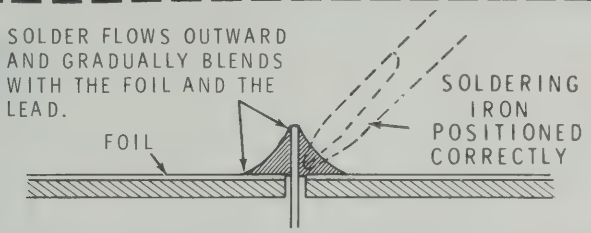


METER RANGE SW SPACERS

.150 Ø BALL BEARING

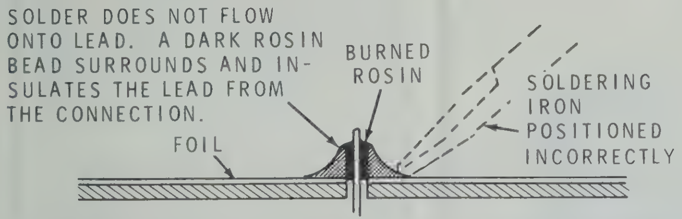
1.09 1.5 110 13AK

A GOOD SOLDER CONNECTION

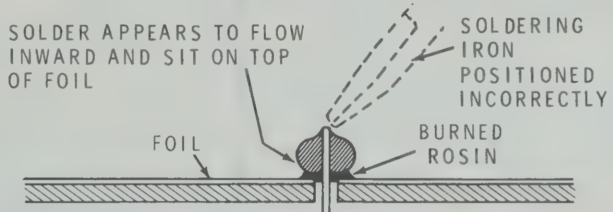

SOLDER FLOWS OUTWARD AND GRADUALLY BLENDS WITH THE FOIL AND THE LEAD.
FOIL
SOLDERING IRON POSITIONED CORRECTLY

When both the lead and the circuit board foil are heated at the same time, the solder will flow onto the lead and the foil evenly. The solder will make a good electrical connection between the lead and the foil.

POOR SOLDER CONNECTIONS


SOLDER DOES NOT FLOW ONTO LEAD. A DARK ROSIN BEAD SURROUNDS AND INSULATES THE LEAD FROM THE CONNECTION.
BURNED ROSIN
SOLDERING IRON POSITIONED INCORRECTLY
FOIL

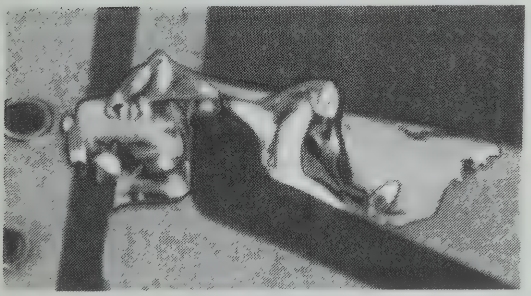
When the lead is not heated sufficiently, the solder will not flow onto the lead as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.


SOLDER APPEARS TO FLOW INWARD AND SIT ON TOP OF FOIL
SOLDERING IRON POSITIONED INCORRECTLY
FOIL
BURNED ROSIN

When the foil is not heated sufficiently the solder will blob on the circuit board as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.

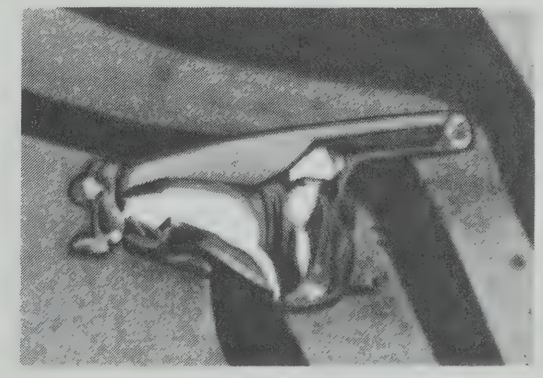
SOLDER CONNECTIONS TO WATCH OUT FOR

The following photographs show examples of the types of bad solder connections that are the most common cause of trouble. If you locate any of these bad solder connections in your kit, correct them as instructed.



Here, hot solder has been dropped onto the foil and the solder connected or bridged (or crossed) three foils. To correct, hold the circuit board above the soldering iron and reheat the solder. As the solder melts, it will flow down the iron.

NOTE: Solder that bridges two connections on the SAME FOIL is alright and should not be corrected.



Here, solder has flowed along a lead and bridged to another foil. To correct, hold the circuit board above the soldering iron and reheat the solder. As the solder melts, it will flow down the iron. Then cut off the excess lead lengths. PROTECT YOUR EYES.

START

(✓) R406: 150 Ω (brown-green-brown). ✓ B

(✓) R407: 150 Ω (brown-green-brown). B

NOTE: When you install a precision resistor, always position it so the value (7320 Ω, etc.) is visible.

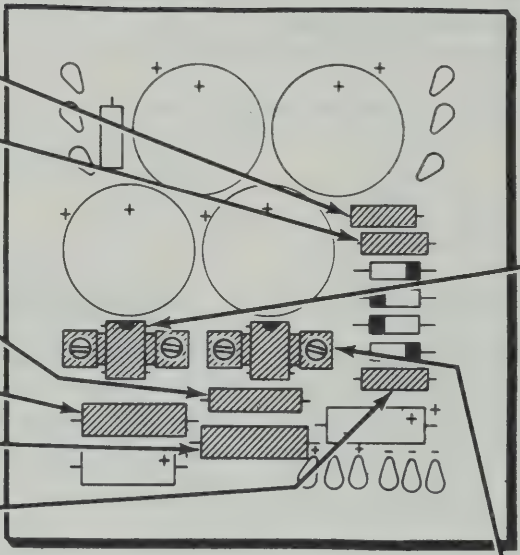
(✓) R402: 7320 Ω (7.320k) precision. B

(✓) R401: 20 kΩ precision. B.

(✓) R403: 22.5 kΩ precision. B

(✓) R405: 47 Ω (yellow-violet-black). B

(✓) Solder the leads to the foil and cut off the excess lead lengths.



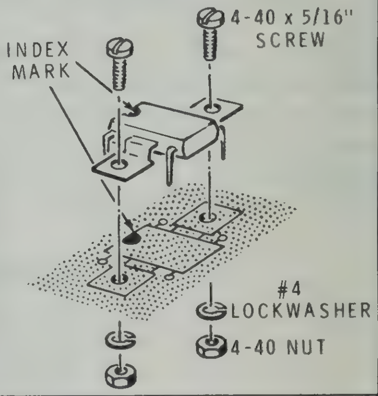
PICTORIAL 1-3

CONTINUE

NOTE: A nut starter is supplied with this kit to hold and start nuts on screws.

(✓) IC401: UA78MGT2C voltage regulator (#442-617). Install the regulator as follows: B

1. Align the index mark on the regulator with the index mark on the circuit board. Then insert the leads into the circuit board holes.
2. Secure the regulator to the circuit board with two 4-40 × 5/16" screws, #4 lockwashers, and 4-40 nuts. DO NOT overtighten the screws.
3. Solder the leads to the foil.



(✓) IC402: In a like manner install a UA79MGT2C voltage regulator (#442-618). B

START

NOTE: During circuit board assembly, you will be instructed to refer to the "Illustration Booklet" for detailed mounting instructions of various components (Figure A, Figure B, etc.). When you install transistors, refer to the large chart (Figure G) on the right side of "Illustration Booklet" Page 3. Follow the instructions at the top of the chart.

(✓) C403: 500 μF electrolytic. Refer to Figure A. B

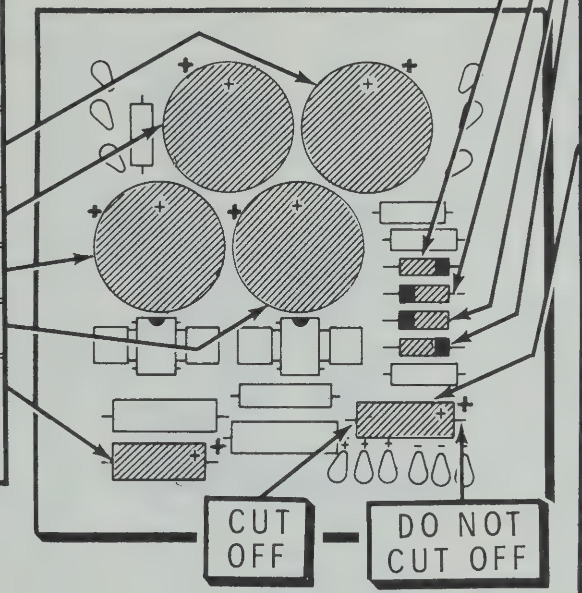
(✓) C402: 500 μF electrolytic. B

(✓) C405: 500 μF electrolytic. B

(✓) C406: 500 μF electrolytic. B

(✓) C401: 1.5 μF electrolytic. B

(✓) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 1-4

CONTINUE

(✓) D404: 1N2071 diode (#57-27). Refer to Figure F. B

(✓) D403: 1N2071 diode (#57-27). B

(✓) D401: 1N2071 diode (#57-27). B

(✓) D402: 1N2071 diode (#57-27). B

(✓) Solder the leads to the foil and cut off the excess lead lengths.

CAUTION: After you install the next part, you will cut off only one lead. Do not cut off the wrong lead.

(✓) C404: 1.5 μF electrolytic. B

(✓) Solder the leads to the foil and cut off the indicated lead from the foil side. DO NOT cut off the other lead. B

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

(✓) Unsoldered connections. Disregard the unused holes.

(✓) "Cold" solder connections.

(✓) Solder bridges between foil patterns.

(✓) Protruding leads which could touch together. Disregard lead from C404.

(✓) Electrolytic capacitors for the correct position of the positive (+) lead.

(✓) Integrated circuits for correct position of index mark.

(✓) Diodes for the correct position of the banded end.

Set this circuit board aside temporarily. Then refer to Page 6 and check the meter amplifier circuit board parts against the "Parts List."

METER AMPLIFIER CIRCUIT BOARD

START

(X) Position the meter amplifier circuit board as shown. Then complete the steps in the following Pictorials.

(✓) R216: 390 kΩ (orange-white-yellow). B

(●) R203: 3000 Ω (orange-black-red).

(●) R204: 510 Ω (green-brown-brown). B

(●) R208: 51 Ω (green-brown-black). B

(●) R209: 6800 Ω (blue-gray-red). B

(✓) Solder the leads to the foil and cut off the excess lead lengths.

(●) R222: 100 Ω (brown-black-brown). B

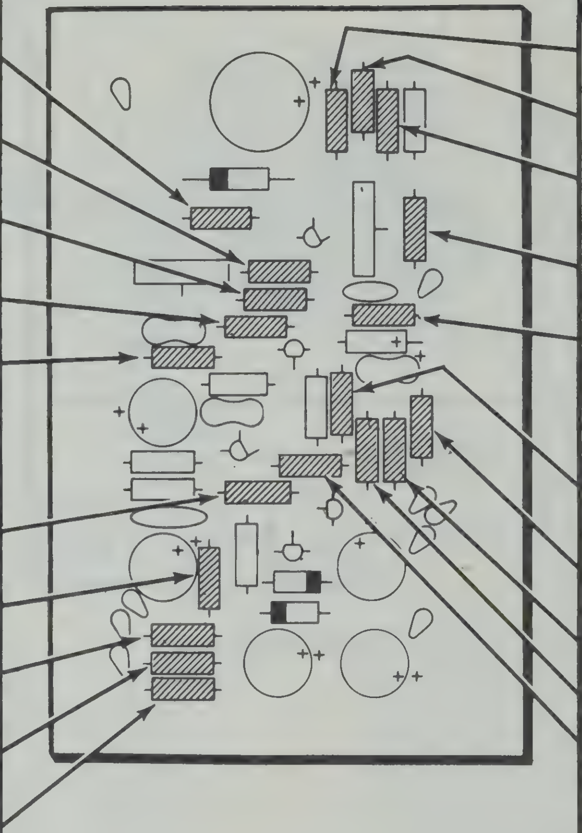
(●) R220: 10 Ω (brown-black-black). B

(●) R225: 510 Ω (green-brown-brown). B

(●) R224: 510 Ω (green-brown-brown). B

(●) R227: 360 Ω (orange-blue-brown). B

(✓) Solder the leads to the foil, and cut off the excess lead lengths.



CONTINUE

(●) R217: 120 kΩ (brown-red-yellow). B

(●) R201: 200 Ω (red-black-brown). B

(●) R206: 10 Ω (brown-black-black). B

(●) R207: 100 Ω (brown-black-brown). B

(●) R213: 24 Ω (red-yellow-black). B

(X) Solder the leads to the foil and cut off the excess lead lengths.

(●) R212: 12 kΩ (brown-red-orange). B

(●) R215: 39 Ω (orange-white-black). B

(●) R226: 2000 Ω (red-black-red). B

(●) R228: 2000 Ω (red-black-red). B

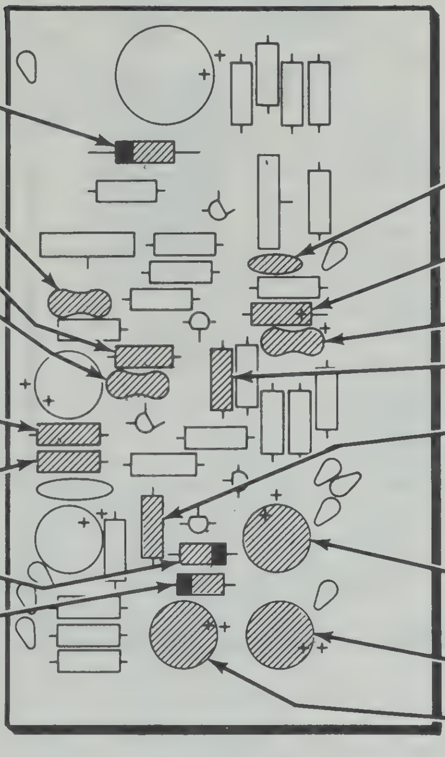
(●) R219: 220 Ω (red-red-brown). B

(X) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-1

START

- (✓) ZD201: 1N4166A zener diode (#56-25). Refer to Figure F.
- (✓) B C204: 160 pF mica.
- (✓) B R210: 200 Ω (red-black-brown).
- (✓) B C207: 240 pF mica.
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) B R218: 3000 Ω (orange-black-red).
- (✓) B R221: 2400 Ω (red-yellow-red).
- (✓) B D203: 1N191 (#56-26, brown-white-brown) diode.
- (✓) B D202: 1N191 (#56-26, brown-white-brown) diode.
- (✓) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

- (✓) B C202: 0.001 μF (1000 pF) ceramic. Refer to Figure B.
- (✓) B C206: 0.47 μF tantalum. Refer to Figure C.
- (✓) B C203: 390 pF mica.
- (✓) B R211: 2000 Ω (red-black-red).
- (✓) B R223: 3000 Ω (orange-black-red).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) B C210: 50 μF electrolytic. Refer to Figure A.
- (✓) B C211: 50 μF electrolytic.
- (✓) B C212: 50 μF electrolytic.
- (✓) B Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 2-2

START

(✓) C201: 1000 μF electrolytic. Solder the leads to the foil and cut off the excess lead lengths.

(✓) R205: 200 Ω control (#10-917). Solder the leads to the foil.

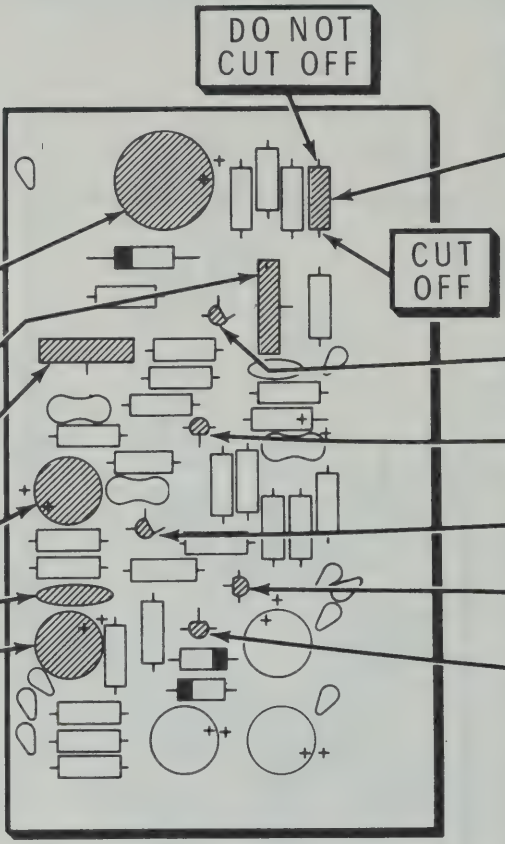
(✓) R202: 20 kΩ control (#10-390). Solder the leads to the foil.

(✓) C205: 100 μF electrolytic.

(✓) C208: 0.1 μF ceramic.

(✓) C209: 100 μF electrolytic.

( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

CAUTION: After you install the next part, cut off the indicated lead only.

(✓) R214: 10 Ω (brown-black-black).

(✓) Solder the leads to the foil and cut off the indicated lead from the foil side. DO NOT cut off the other lead.

(✓) Q201: 2N3416 transistor (#417-94). See Figure G.

(✓) Q202: 2N4121 transistor (#417-235).

(✓) Q203: 2N3416 transistor (#417-94).

(✓) Q204: 2N4121 transistor (#417-235).

(✓) Q205: 2N4121 transistor (#417-235).

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

(✓) Unsoldered connections. Disregard the unused holes.

( ) Poor solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together. Disregard lead from R214.

( ) Transistors for the proper **type** and **installation**.

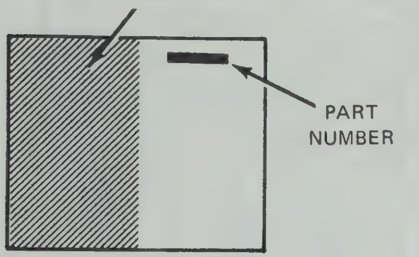
( ) Electrolytic and tantalum capacitors for the correct position of the positive (+) lead.

( ) Diodes for the correct position of the banded end.

Set this circuit board aside temporarily. Then refer to Page 7 and check the bridge amplifier circuit board parts against the "Parts List."

PICTORIAL 2-3

BRIDGE AMPLIFIER CIRCUIT BOARD


The steps performed in this Pictorial are in this area of the circuit board.

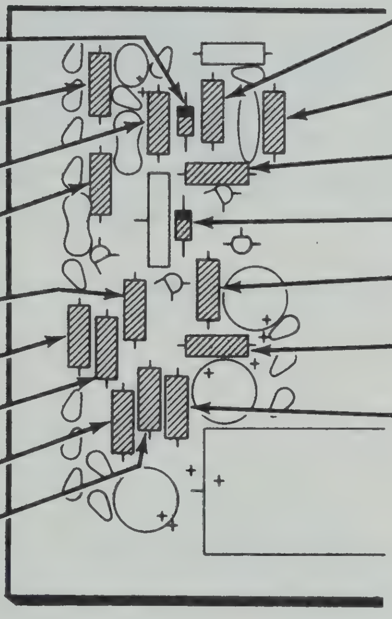
IDENTIFICATION DRAWING

START

- (✓) Position the bridge amplifier circuit board as shown. Then complete the steps in the following Pictorials.
- (✓) D101: 1N4149 diode (#56-56). See Figure F.
- (✓) R112: 1000 Ω (brown-black-red).
- (✓) R107: 8200 Ω (gray-red-red).
- (✓) R114: 6800 Ω (blue-gray-red).
- (✓) R115: 150 Ω (brown-green-brown).
- (✓) R110: 200 Ω (red-black-brown).
- (✓) R111: 3600 Ω (orange-blue-red).
- (✓) R137: 24 Ω (red-yellow-black).
- (✓) R117: 20 kΩ (red-black-orange).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

- (✓) R102: 100 kΩ (brown-black-yellow).
- (✓) R103: 100 Ω (brown-black-brown).
- (✓) R104: 10 kΩ (brown-black-orange).
- (✓) D102: 1N4149 diode (#56-56).
- (✓) R105: 2200 Ω (red-red-red).
- (✓) R106: 240 Ω (red-yellow-brown).
- (✓) R109: 120 kΩ (brown-red-yellow).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 3-1

START

( ) C101: 0.01 μF ceramic. Refer to Figure B.

( ) C104: 4.7 μF tantalum. Refer to Figure D.

( ) C105: 30 pF mica.

( ) R108: 20 kΩ control (#10-390). Solder the control leads to the foil.

( ) C108: 240 pF mica.

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) Q104: 2N3416 transistor (#417-94). Refer to Figure G.

( ) Q103: 2N3416 transistor (#417-94).

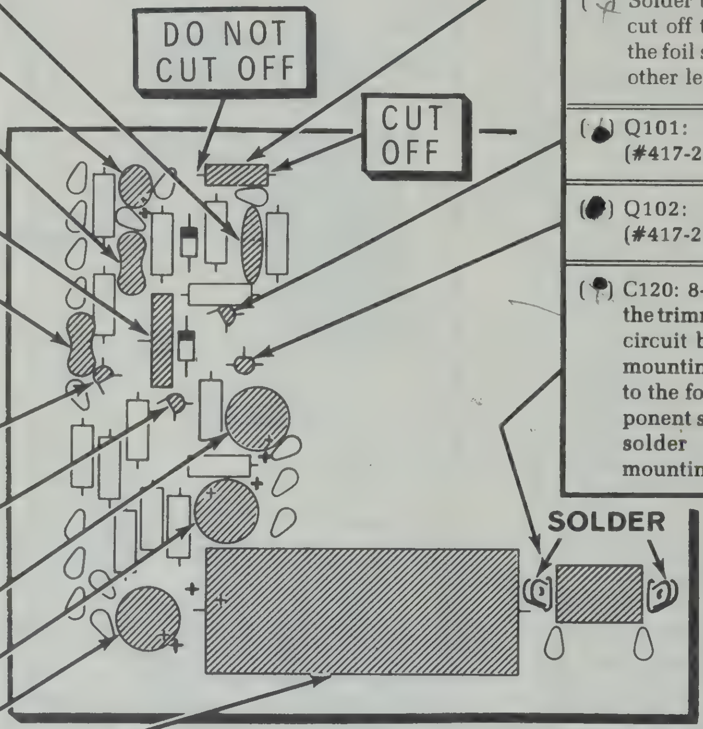
( ) C102: 100 μF electrolytic. Refer to Figure A.

( ) C103: 100 μF electrolytic.

( ) C107: 100 μF electrolytic.

( ) C106: 200 μF electrolytic.

( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

CAUTION: After you install the next part, cut off the indicated lead only.

( ) R101: 22 MΩ (red-red-blue).

( ) Solder the leads to the foil and cut off the indicated lead from the foil side. DO NOT cut off the other lead.

( ) Q101: Selected transistor (#417-222).

( ) Q102: 2N4121 transistor (#417-235).

( ) C120: 8-60 pF trimmer. Mount the trimmer to the foil side of the circuit board. Do not bend the mounting tabs. Solder the tabs to the foil. Then, from the component side of the circuit board, solder the leaves on each mounting tab together.

PICTORIAL 3-2

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections. Disregard the unused holes.

( ) Poor solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together. Disregard lead from R101.

( ) Transistors for the proper **type** and **installation**.

( ) Electrolytic capacitors for the correct position of the positive (+) lead.

( ) Diodes for the correct position of the banded end.

Set this circuit board aside temporarily. Then refer to Page 8 and check the null amplifier circuit board parts against the "Parts List."

NULL AMPLIFIER CIRCUIT BOARD

START

(✓) Position the null amplifier circuit board as shown. Then complete the steps in the following Pictorials.

(✓) R132: 7500 Ω (violet-green-red).

(✓) R118: 470 Ω (yellow-violet-brown).

(✓) R130: 300 Ω, 1/4-watt (orange-black-brown).

(✓) R129: 560 Ω (green-blue-brown).

(✓) R131: 2000 Ω (red-black-red).

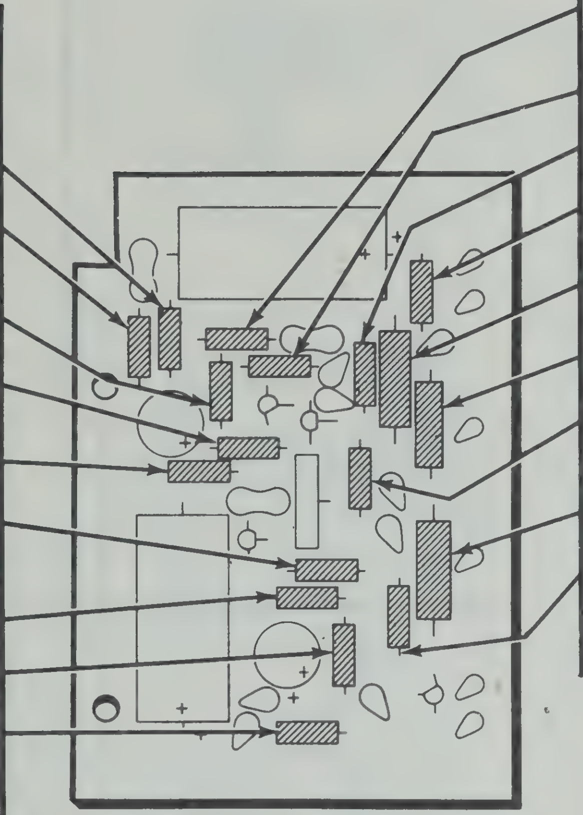
(✓) R124: 1500 Ω (brown-green-red).

(✓) R135: 47 Ω (yellow-violet-black).

(✓) R134: 2000 Ω (red-black-red).

(✓) R136: 10 kΩ (brown-black-orange).

(✓) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

(✓) R133: 330 Ω (orange-orange-brown).

(✓) R128: 3600 Ω (orange-blue-red).

(✓) R126: 7500 Ω (violet-green-red).

(✓) R122: 33 kΩ (orange-orange-orange).

(✓) R120: 2725 Ω (2.725k) precision.

(✓) R121: 13 kΩ, 1/4-watt precision.

(✓) R123: 10 MΩ (brown-black-blue).

(✓) R113: 2725 Ω (2.725k) precision.

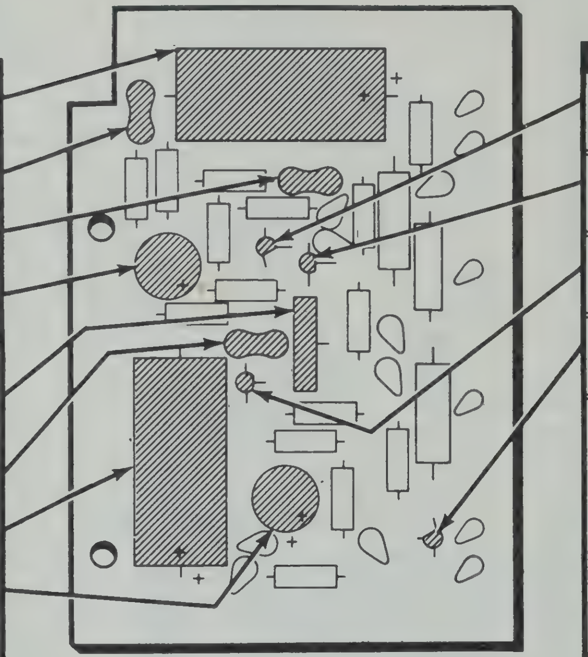
(✓) R116: 2700 Ω (red-violet-red).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 4-1

START

- (✓) C109: 500 μF electrolytic. Refer to Figure A.
- (✓) C110: 56 pF mica.
- (✓) C113: 150 pF mica.
- (✓) C112: 250 μF electrolytic. Refer to Figure A.
- (✓) R125: 5000 Ω (5 k) control (#10-904). Solder the control leads to the foil.
- (✓) C114: 125 pF mica.
- (✓) C116: 500 μF electrolytic.
- (✓) C115: 250 μF electrolytic.
- (✓) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

- (✓) Q107: 2N3416 transistor (#417-94). Refer to Figure G.
- (✓) Q106: Selected FET transistor (#417-878).
- (✓) Q108: 2N4121 transistor (#417-235).
- (✓) Q105: 2N3416 transistor (#417-94).

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

- ( ) Unsoldered connections. Disregard the unused holes.
- ( ) Poor solder connections.
- ( ) Solder bridges between the foil patterns.
- ( ) Protruding leads which could touch together.
- ( ) Transistors for the proper **type** and **installation.**
- ( ) Electrolytic capacitors for the correct position of the positive (+) lead.

Set this circuit board aside temporarily. Then refer to Page 9 and check the auto null amplifier circuit board parts against the "Parts List."

PICTORIAL 4-2

AUTO NULL AMPLIFIER CIRCUIT BOARD

START

(✓) Position the auto null amplifier circuit board as shown. Then complete the steps in the following Pictorials.

(✓) R341: 12 kΩ (brown-red-orange).

(✓) R342: 12 kΩ (brown-red-orange).

(✓) R343: 10 kΩ (brown-black-orange).

(✓) R344: 10 kΩ (brown-black-orange).

( ) R369: 10 kΩ (brown-black-orange).

(✓) R368: 10 kΩ (brown-black-orange).

(✓) R370: 30 kΩ (orange-black-orange).

(✓) R364: 3300 Ω (orange-orange-red).

(✓) R363: 3300 Ω (orange-orange-red).

(✓) R362: 3300 Ω (orange-orange-red).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

(✓) R359: 120 Ω (brown-red-brown).

( ) R354: 360 Ω (orange-blue-brown).

(✓) R356: 18 kΩ (brown-gray-orange).

(✓) R352: 36 kΩ (orange-blue-orange).

(✓) R350: 10 kΩ (brown-black-orange).

(✓) R347: 200 Ω (red-black-brown).

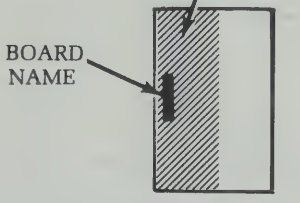
(✓) R314: 200 Ω (red-black-brown).

(✓) R348: 10 kΩ (brown-black-orange).

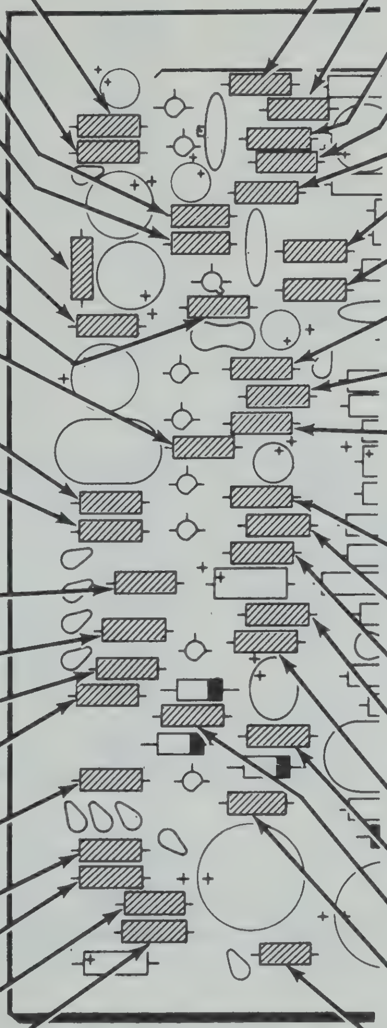
(✓) R315: 10 kΩ (brown-black-orange).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

The steps performed in this Pictorial are in this area of the circuit board.



IDENTIFICATION DRAWING



CONTINUE

(✓) R336: 10 kΩ (brown-black-orange).

(✓) R340: 12 kΩ (brown-red-orange).

(✓) R338: 100 Ω (brown-black-brown).

(✓) R339: 100 Ω (brown-black-brown).

(✓) R337: 10 kΩ (brown-black-orange).

(✓) R345: 750 kΩ (violet-green-yellow).

(✓) R371: 68 kΩ (blue-gray-orange).

(✓) R366: 10 kΩ (brown-black-orange).

(✓) R367: 10 kΩ (brown-black-orange).

(✓) R365: 10 kΩ (brown-black-orange).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

(✓) R360: 10 kΩ (brown-black-orange).

(✓) R361: 3300 Ω (orange-orange-red).

(✓) R358: 10 kΩ (brown-black-orange).

(✓) R355: 8200 Ω (gray-red-red).

(✓) R353: 160 Ω (brown-blue-brown).

(✓) R349: 22 kΩ (red-red-orange).

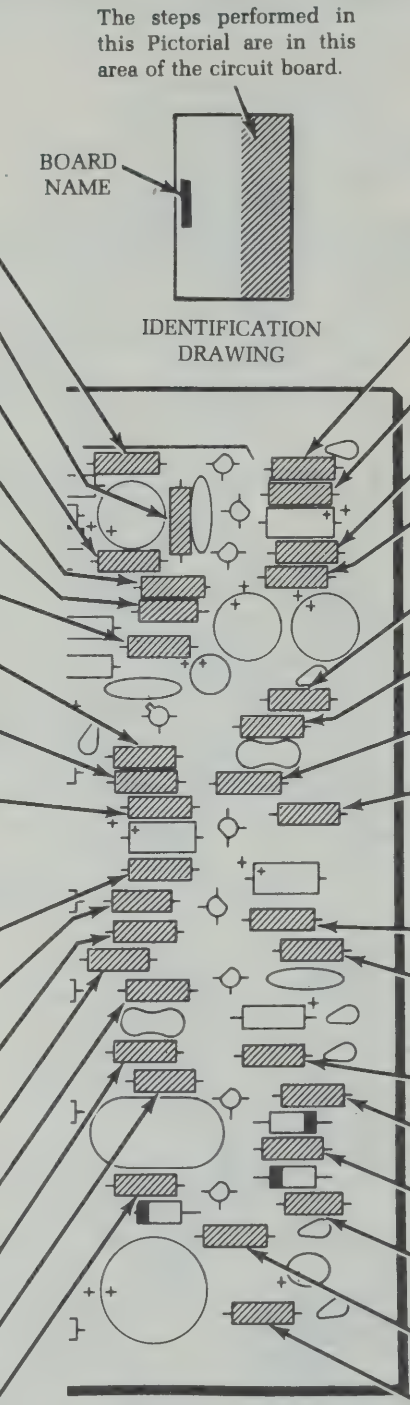
(✓) R351: 2000 Ω (red-black-red).

(✓) R346: 10 Ω (brown-black-black).

(✓) R335: 10 Ω (brown-black-black).

(✓) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 5-1


The steps performed in this Pictorial are in this area of the circuit board.
BOARD NAME
IDENTIFICATION DRAWING

START

- (✓) R303: 27 kΩ (red-violet-orange).
- (✓) R307: 100 Ω (brown-black-brown).
- (✓) R309: 12 kΩ (brown-red-orange).
- (✓) R308: 100 Ω (brown-black-brown).
- ( ) R304: 10 kΩ (brown-black-orange).
- (✓) R312: 750 kΩ (violet-green-yellow).
- (✓) R333: 68 kΩ (blue-gray-orange).
- (✓) R328: 10 kΩ (brown-black-orange).
- (✓) R327: 10 kΩ (brown-black-orange).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) R326: 10 kΩ (brown-black-orange).
- (✓) R324: 10 kΩ (brown-black-orange).
- (✓) R331: 180 kΩ (brown-gray-yellow).
- (✓) R357: 2200 Ω (red-red-red).
- ( ) R323: 100 kΩ (brown-black-yellow).
- (✓) R322: 5600 Ω (green-blue-red).
- (✓) R320: 160 Ω (brown-blue-brown).
- (✓) R316: 22 kΩ (red-red-orange).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

- (✓) R301: 22 kΩ (red-red-orange).
- (✓) R302: 10 kΩ (brown-black-orange).
- (✓) R305: 12 kΩ (brown-red-orange).
- (✓) R306: 12 kΩ (brown-red-orange).
- (✓) R310: 10 kΩ (brown-black-orange).
- (✓) R311: 10 kΩ (brown-black-orange).
- (✓) R332: 30 kΩ (orange-black-orange).
- (✓) R330: 10 kΩ (brown-black-orange).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.
- (✓) R329: 10 kΩ (brown-black-orange).
- (✓) R325: 5100 Ω (green-brown-red).
- (✓) R321: 360 Ω (orange-blue-brown).
- (✓) R319: 36 kΩ (orange-blue-orange).
- (✓) R318: 2000 Ω (red-black-red).
- (✓) R317: 10 kΩ (brown-black-orange).
- (✓) R313: 4.7 Ω (yellow-violet-gold).
- (✓) R334: 10 Ω (brown-black-black).
- (✓) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 5-2

START

NOTE: To prepare a wire, as in the next step, cut it to the indicated length and remove 1/4" of insulation from each end.

(✓) Prepare and install a 2-1/2" black wire.

(✓) Q310: Selected transistor (#417-283). Refer to Figure G.

(✓) Q311: Selected transistor (#417-283).

(✓) Q312: 2N2432 transistor (#417-886).

(✓) Q318: 2N3646 transistor (#417-93).

(✓) Q317: 2N3646 transistor (#417-93).

(✓) Q316: Selected transistor (#417-283).

(✓) Q315: Selected transistor (#417-283).

(✓) Q314: Selected transistor (#417-283).

(✓) D306: 1N458 diode (#56-24). Refer to Figure F.

(✓) D305: 1N458 diode (#56-24).

(✓) Q313: Selected transistor (#417-283). Refer to Figure G.

(✓) D304: 1N191 (brown-white-brown) diode (#56-26). Refer to Figure F.

(✓) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

(✓) Q301: Selected transistor (#417-283).

(✓) Q302: Selected transistor (#417-283).

(✓) Q303: Selected transistor (#417-283).

(✓) Q304: 2N2432 transistor (#417-886).

(✓) Q309: 2N3646 transistor (#417-93).

(✓) Q308: 2N3646 transistor (#417-93).

(✓) Q307: Selected transistor (#417-283).

(✓) Q306: Selected transistor (#417-283).

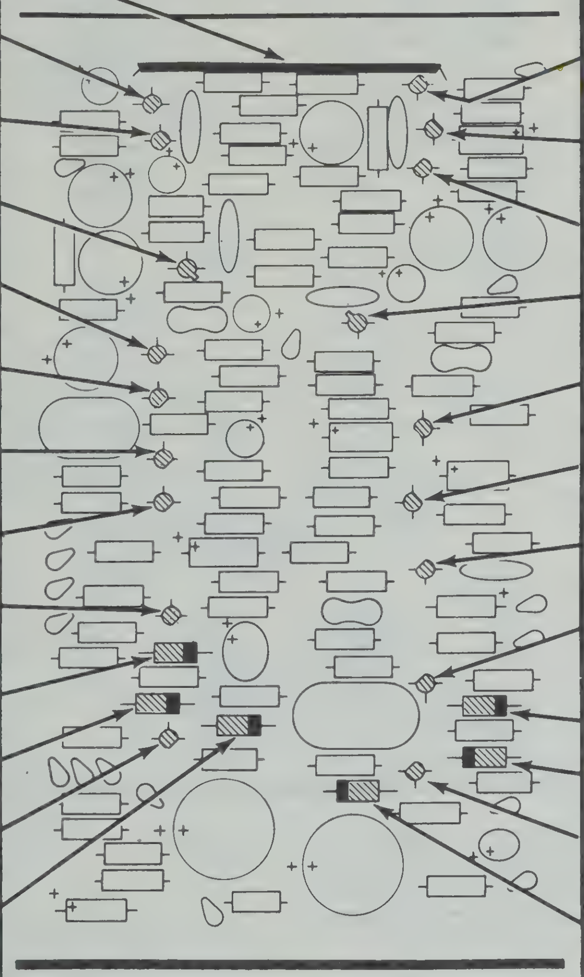
(✓) D303: 1N458 diode (#56-24). Refer to Figure F.

(✓) D302: 1N458 diode (#56-24).

(✓) Q305: Selected transistor (#417-283). Refer to Figure G.

(✓) D301: 1N191 (brown-white-brown) diode (#56-26). Refer to Figure F.

(✓) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 5-3

START

(✓) C317: 10 μF electrolytic. Refer to Figure A.

(✓) C330: 0.01 ceramic. Refer to Figure B.

(✓) C318: 10 μF electrolytic.

(✓) C320: 50 μF electrolytic.

(✓) C319: 50 μF electrolytic.

(✓) C321: 0.01 μF ceramic.

(✓) C329: 33 pF mica.

(✓) Solder the leads to the foil and cut off the excess lead lenghts.

(✓) C326: 22 μF electrolytic.

(✓) C327: 0.0047 μF (4700 pF) Mylar. Disregard any polarity marks.

(✓) C328: 10 μF electrolytic.

(✓) C325: 10 μF electrolytic.

(✓) C324: 33 μF tantalum. Refer to Figure E.

(✓) C323: 2.2 μF tantalum. Refer to Figure D.

(✓) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

(✓) C302: 500 μF electrolytic.

(✓) C303: 0.01 μF ceramic.

(✓) C301: 33μF tantalum.

(✓) C306: 50 μF electrolytic.

(✓) C305: 50 μF electrolytic.

(✓) C304: 10 μF electrolytic.

(✓) C307: 0.01 μF ceramic.

(✓) C314: 33 pF mica.

(✓) Solder the leads to the foil and cut off the excess lead lengths.

(✓) C312: 33 μF tantalum.

(✓) C313: 33 μF tantalum.

(✓) C311: 0.01 μF ceramic.

(✓) C310: 0.22 μF tantalum.

(✓) C309: 130 pF mica.

(✓) C331: 0.01 μF Mylar. Disregard any polarity marks.

(✓) C315: 4.7 μF tantalum.

(✓) C308: 2500 μF electrolytic.

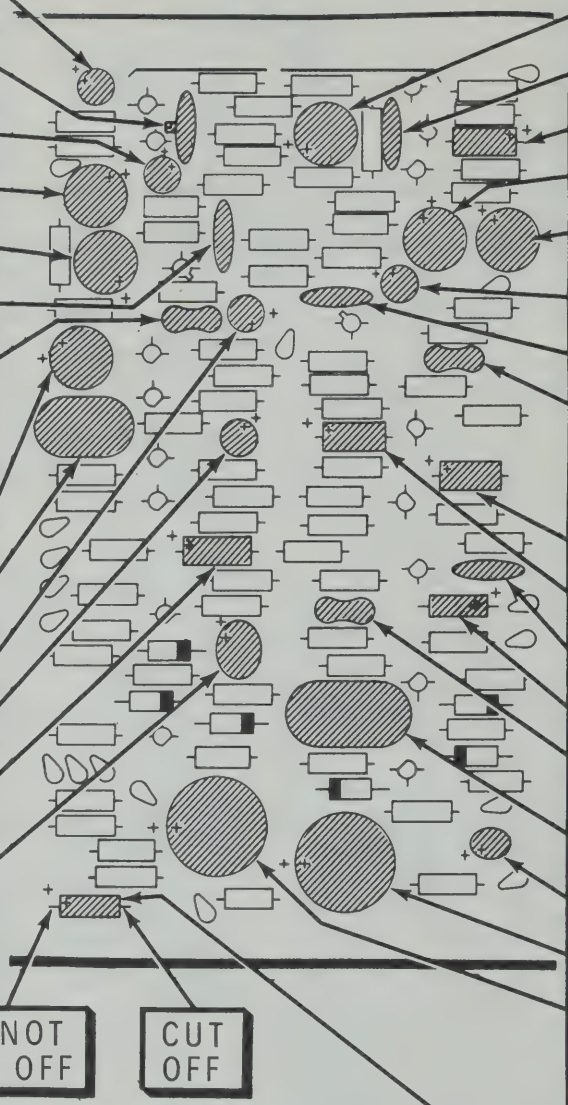
(✓) C322: 2500 μF electrolytic.

(✓) Solder the leads to the foil and cut off the excess lead lengths.

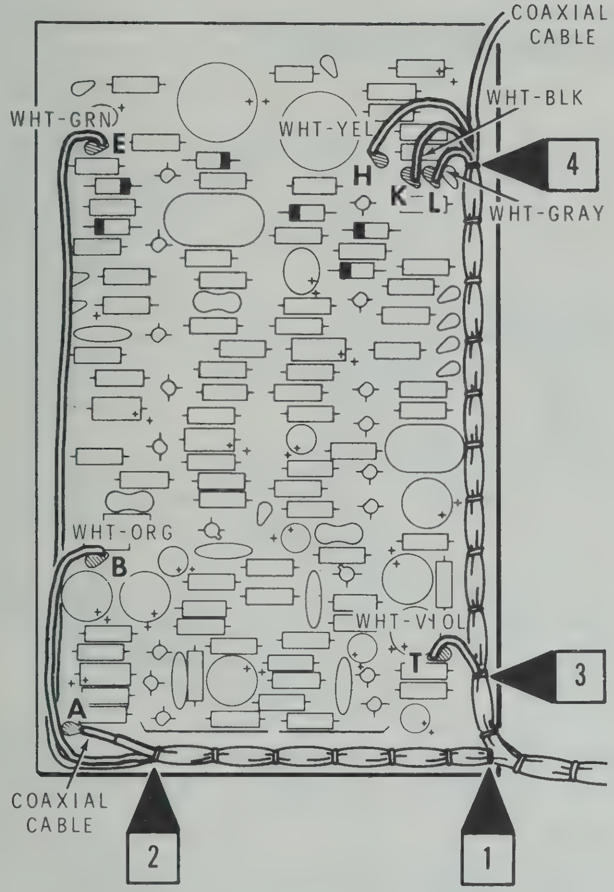
CAUTION: After you install the next part, cut off the indicated lead only.

(✓) C316: 0.22 μF tantalum. Refer to Figure C.

(✓) Solder the leads to the foil and cut off the indicated lead on the foil side of the circuit board. DO NOT cut off the other lead.



PICTORIAL 5-4



PICTORIAL 5-5

Refer to Pictorial 5-5 for the following steps.

(✓) Position the auto null amplifier circuit board as shown.

(✓) Locate wire harness (#134-965) and position the wires around the circuit board as shown. Note the various places the individual wires leave the harness. These are called breakouts and serve as wire locators in the assembly steps.

Connect the harness wires from breakouts 3, 4, and 2 as described in the following steps. As you install each wire, solder it to the circuit board and cut off the excess wire length.

(✓) White-violet wire to hole T.

(✓) White-gray wire to hole L.

(✓) White-black wire to hole K.

(✓) White-yellow wire to hole H.

NOTE: The coaxial cable from breakout 4 will be connected in a later step.

(✓) Coaxial cable from breakout 2 to hole A.

(✓) White-orange wire to hole B.

(✓) White-green wire to hole E.

Carefully examine the circuit board for the following conditions:

( ) Unsoldered connections. Disregard unused holes.

( ) "Cold" solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together. Disregard lead from C316.

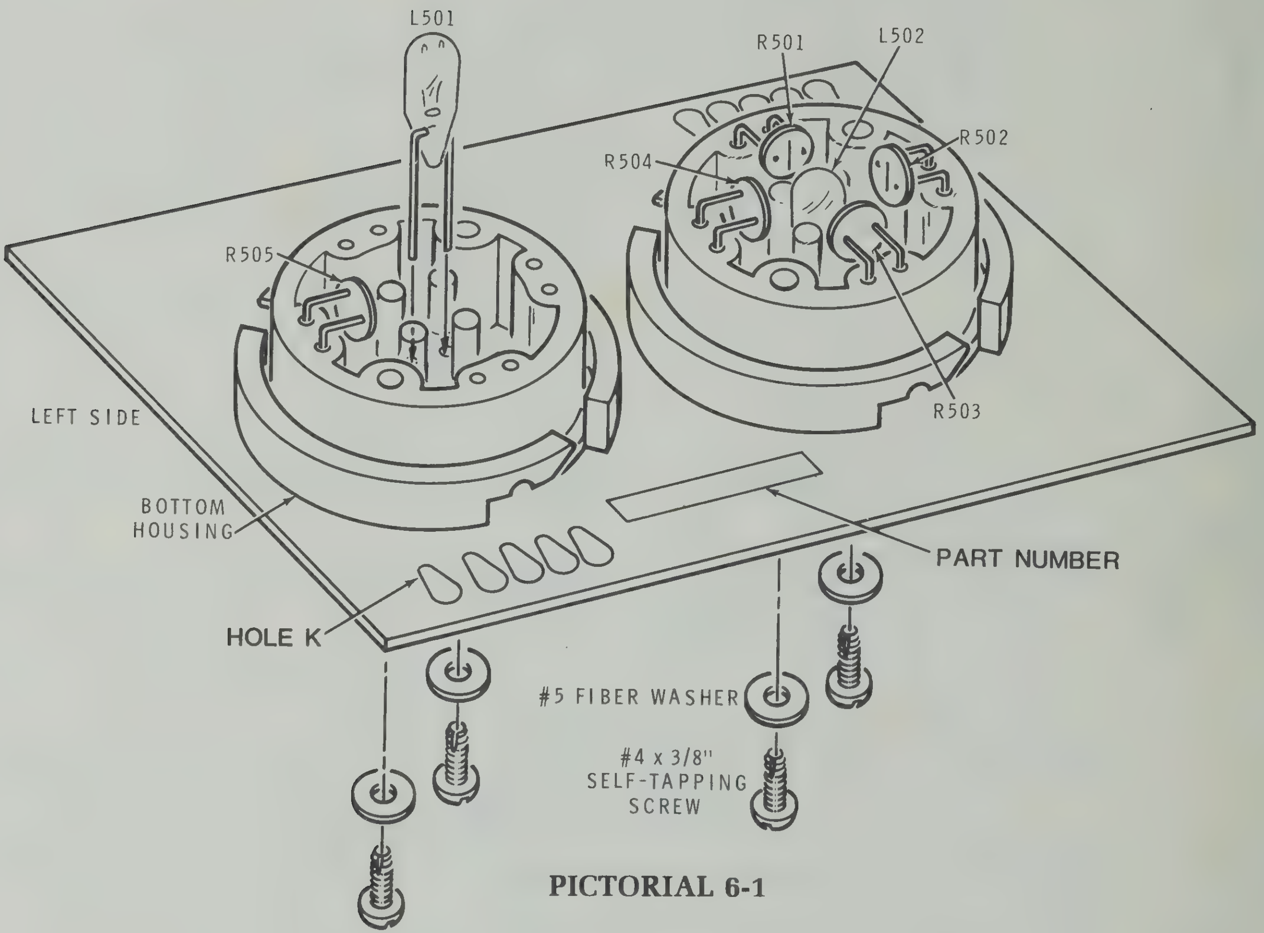
( ) Transistors for the proper type and installation.

( ) Capacitors for the correct position of the positive (+) lead.

( ) Diodes for the proper type and installation.

Set this circuit board aside temporarily. Then refer to Page 10 and check the optical isolator circuit board parts against the "Parts List."

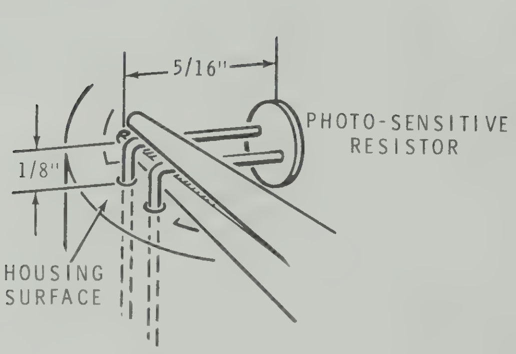
OPTICAL ISOLATOR CIRCUIT BOARD



PICTORIAL 6-1

Refer to Pictorial 6-1 for the following steps. NOTE: The photosensitive resistor leads have been shortened in this illustration for clarity.

- ☑ Position the optical isolator circuit board as shown with the foil side down.
- ☑ Lay a bottom housing on the left side of the circuit board and align the mounting holes.
- ☑ Refer to Detail 6-1A and sharply bend the leads of a 100 kΩ photosensitive resistor (#9-70) 5/16" from the end of the resistor body. Hold the leads between the bend point and resistor body with long-nose pliers. This will prevent possible damage to the resistor.



Detail 6-1A

☒ R505: Pass the leads of the prepared 100 kΩ photosensitive resistor through the housing holes and circuit board holes. Do not solder the leads to the foil.

☒ L501: Carefully bend the leads of an incandescent lamp down as shown. Then insert the leads through the housing holes and circuit board holes. Press the lamp down between the locating posts.

☒ Secure the housing to the circuit board with two #4 × 3/8" self-tapping screws and two #5 fiber washers.

☒ Make sure the lamp is pressed into the housing. Then solder its leads to the foil and cut off the excess lead lengths.

☒ Position the photosensitive resistor 1/8" above the housing surface as shown in Detail 6-1A. Then solder its leads to the foil and cut off the excess lead lengths.

☒ Lay a bottom housing on the right side of the circuit board and align the mounting holes.

☒ R504: Sharply bend the leads of a 100 kΩ photosensitive resistor (#9-70) 5/16" from the end of the resistor body. Then pass the leads through the housing holes and circuit board holes at R504.

☒ R502: In a like manner, prepare and install a 100 kΩ photosensitive resistor (#9-70) at R502.

☒ R501: In a like manner, prepare and install a 700 kΩ photosensitive resistor (#9-71) at R501.

☒ R503: In a like manner, prepare and install a 700 kΩ photosensitive resistor (#9-71) at R503.

☒ L502: Carefully bend the leads of an incandescent lamp down. Then insert the leads through the housing holes and circuit board holes. Press the lamp down between the locating posts.

☒ Secure the housing to the circuit board with two #4 × 3/8" self-tapping screws and two #5 fiber washers.

☒ Make sure the lamp is pressed into the housing. Then solder its leads to the foil and cut off the excess lead lengths.

☒ Position the four photosensitive resistors 1/8" above the housing surface as shown in Detail 6-1A. Then solder the leads to the foil and cut off the excess lead lengths.

Refer to Pictorial 6-2 for the following steps.

☒ Carefully position a top housing over a bottom housing and fit the two latch pins into the two skirt slots. Turn the top housing clockwise until it snaps in place.

☒ Install a second top housing over the other bottom housing.

☒ Prepare the following wires:

3" white
2" red
7" red
6" white

Install the wires in the following steps. As you install each wire, solder it to the circuit board and cut off any excess wire from the foil side.

☒ 3" white wire to hole J.

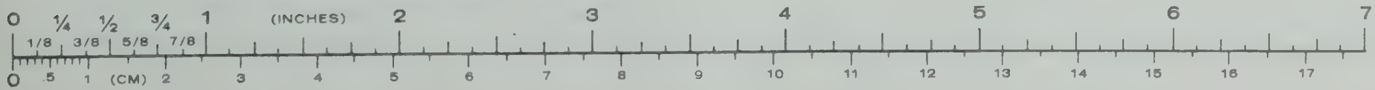
☒ 2" red wire to hole H.

☒ 7" red wire to hole G.

☒ 6" white wire to hole F.

☒ Carefully examine the circuit board for "cold" solder connections or solder bridges between foil patterns.

Set this circuit board aside temporarily. Then refer to Page 11 and check the chassis parts (remaining parts) against the "Parts List."



CHASSIS

Before you begin assembly of the chassis, you will prepare a number of subassemblies (switches and trimmers). Be very careful. Any error in assembly will be difficult to see after you complete the construction of your Harmonic Distortion Analyzer.

METER RANGE SWITCH (SW4)

Refer to Pictorial 7-1 for the following steps.

(✓) Locate the meter range switch (#63-1262) and position it as shown in the Pictorial.

NOTE: There are three wafers with lugs, and a metal plate on this switch. Only the wafers will be identified by number in the assembly instructions. Each wafer can accommodate up to twelve lugs. Each lug will be identified by **position number.** Therefore, if a wafer has only five lugs, they **will not** be numbered 1 through 5. In the assembly steps, each lug will be identified by wafer number and lug number (i.e. wafer 3 lug 6).

(✓) Prepare five 1-3/4″ bare wires from the black wire.

Connect the bare wires between wafers 2 and 3 in the following steps. Do not solder the wires.

(✓) 1-3/4″ bare wire from wafer 3 lug 6 to wafer 2 lug 5.

(✓) 1-3/4″ bare wire from wafer 3 lug 5 to wafer 2 lug 4.

(✓) 1-3/4″ bare wire from wafer 3 lug 4 to wafer 2 lug 3.

(✓) 1-3/4″ bare wire from wafer 3 lug 3 to wafer 2 lug 2.

(✓) 1-3/4″ bare wire from wafer 3 lug 2 to wafer 2 lug 1.

NOTE: After a wire or component lead is connected in a step, an abbreviated solder instruction will also be given. (NS) means not to solder, because other wires will be added later. "S-" with a number, such as (S-3), means to solder the connection. The number following the "S-" tells how many wires are at the connection.

NOTE: When you install a precision resistor, position the value so it is visible.

(✓) R31: Connect a 3.162 Ω precision resistor from wafer 3 lug 6 (S-2) to wafer 2 lug 6 (NS). Cut off any excess lead lengths.

(✓) Prepare a 4″ black wire and connect either end to wafer 2 lug 6 (S-2). The free end of the wire will be connected in a later step.

NOTE: After you install the next five resistors, cut off any excess lead lengths.

(✓) R30: Connect a 6.838 Ω precision resistor from wafer 3 lug 5 (S-2) to wafer 2 lug 5 (S-2).

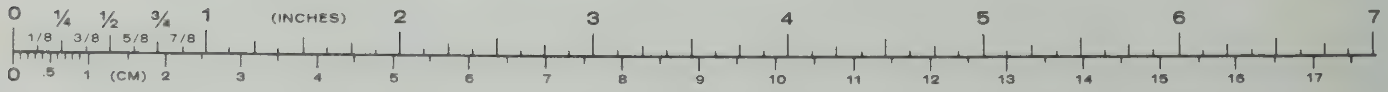
(✓) R29: Connect a 21.62 Ω precision resistor from wafer 3 lug 4 (S-2) to wafer 2 lug 4 (S-2).

(✓) R28: Connect a 68.38 Ω precision resistor from wafer 3 lug 3 (S-2) to wafer 2 lug 3 (S-2).

(✓) R27: Connect a 216.2 Ω precision resistor from wafer 3 lug 2 (S-2) to wafer 2 lug 2 (S-2).

(✓) R26: Connect a 683.8 Ω precision resistor from wafer 3 lug 1 (NS) to wafer 2 lug 1 (S-2).

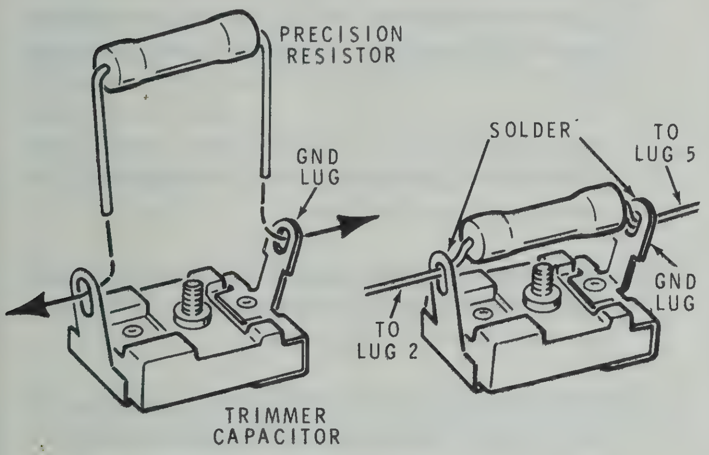
( ) Prepare a 1-1/2″ black wire and connect either end to wafer 1 lug 5 (NS). Pass the other end through the switch between wafer 1 and the metal plate.



Prepare a resistor/trimmer assembly in the next two steps.

(✓) Locate a 1.5-20 pF trimmer capacitor and turn the trim screw into the trimmer body. Do not overtighten the screw.

(✓) Refer to Detail 7-1A and pass the leads of a 999 kΩ precision resistor through the lugs of the trimmer. Then solder the resistor leads to the trimmer lugs. Do not cut off the resistor leads.



Detail 7-1A

( ) R1/C2: Connect the resistor/trimmer assembly to wafer 1: trimmer ground lug (see Detail 7-1A) to lug 5 (S-2) and the other trimmer lug to lug 2 (NS). Use the resistor leads to make the connections. Cut off the excess lead lengths. Position the trimmer out over the edge of the wafer, with the resistor along the edge of the wafer.

NOTE: Whenever you are instructed to prepare a coaxial cable, cut the cable to the indicated length and prepare the ends as shown in Detail 7-1B.

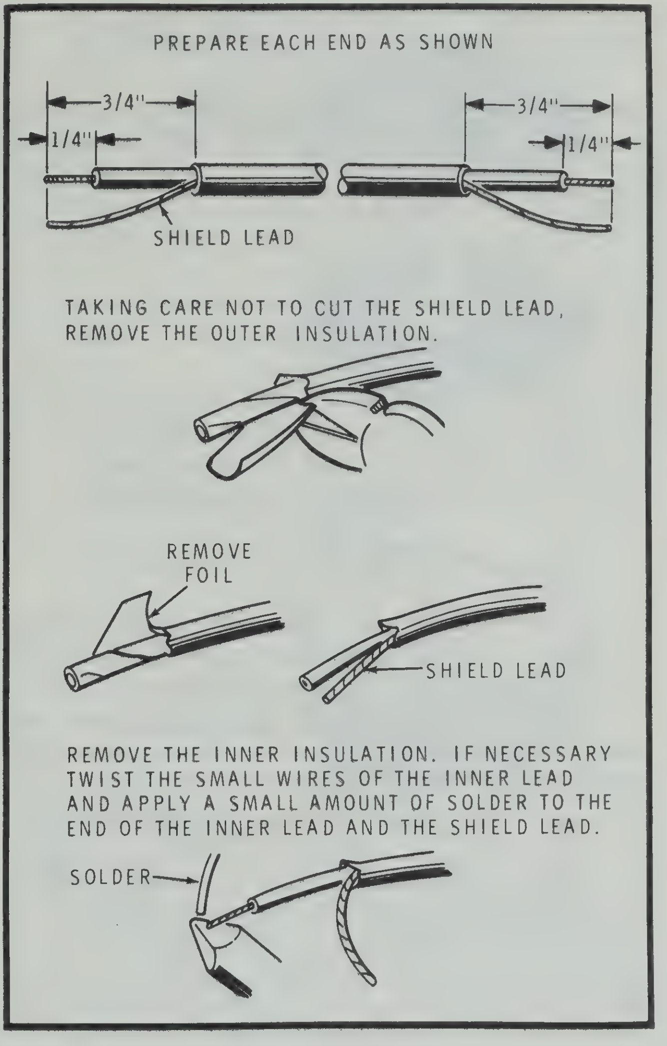
(✓) Prepare a 6-3/4" coaxial cable.

(✓) Connect the inner lead from either end of the coaxial cable to wafer 1 lug 2 (S-2).

(✓) Lay the shield lead against the metal plate and solder the lead to the plate as shown.

(✓) Refer to Detail 7-1C and cut the number label down its length between the 2-3, 8-9 number series. You will use the label half with letters for coaxial cable identification.

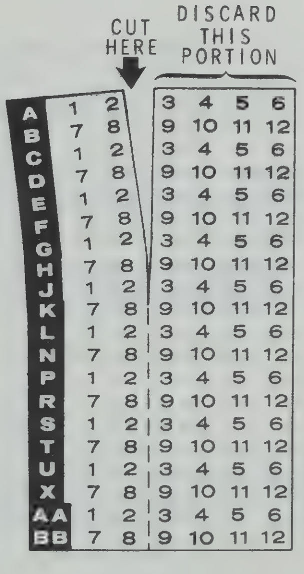
(✓) Carefully remove label strip A12 from the number label and wrap label strip A12 around the free end of the coaxial cable connected to the meter range switch.


PREPARE EACH END AS SHOWN

TAKING CARE NOT TO CUT THE SHIELD LEAD, REMOVE THE OUTER INSULATION.

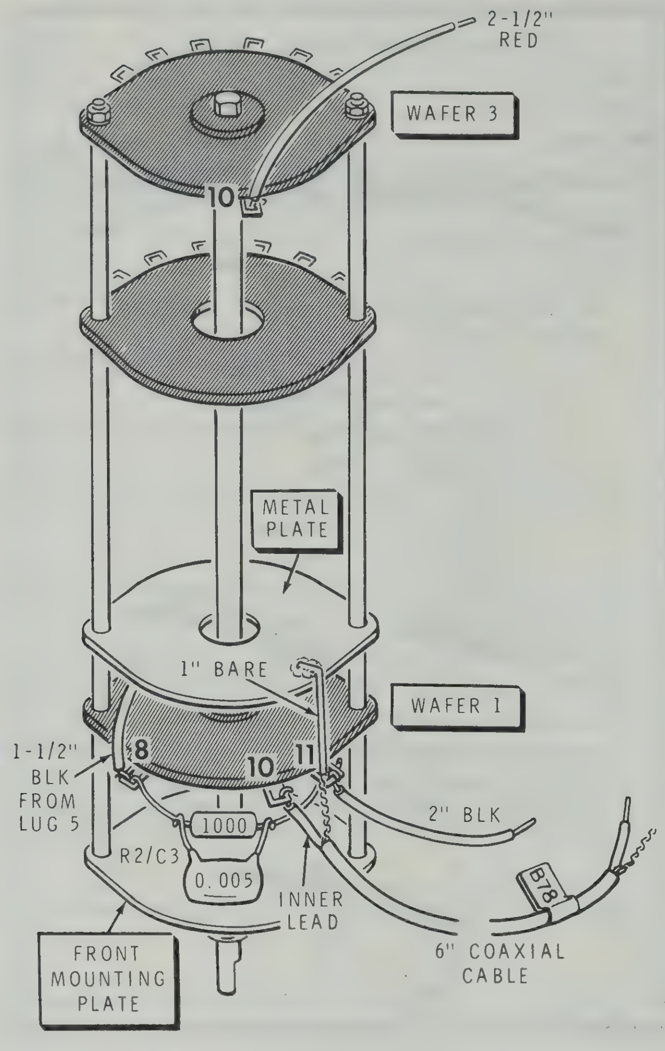
REMOVE THE INNER INSULATION. IF NECESSARY TWIST THE SMALL WIRES OF THE INNER LEAD AND APPLY A SMALL AMOUNT OF SOLDER TO THE END OF THE INNER LEAD AND THE SHIELD LEAD.

Detail 7-1B



A	1	2	3	4	5	6
B	7	8	9	10	11	12
C	1	2	3	4	5	6
D	7	8	9	10	11	12
E	1	2	3	4	5	6
F	7	8	9	10	11	12
G	1	2	3	4	5	6
H	7	8	9	10	11	12
J	1	2	3	4	5	6
K	7	8	9	10	11	12
L	1	2	3	4	5	6
N	7	8	9	10	11	12
P	1	2	3	4	5	6
R	7	8	9	10	11	12
S	1	2	3	4	5	6
T	7	8	9	10	11	12
U	1	2	3	4	5	6
X	7	8	9	10	11	12
AA	1	2	3	4	5	6
BB	7	8	9	10	11	12

Detail 7-1C



PICTORIAL 7-2

Refer to Pictorial 7-2 for the following steps.

(✓) Reposition the meter range switch as shown.

(✓) Refer to Detail 7-2A and wrap the leads of a 0.005 μF (5000 pF) Mylar capacitor around the leads of a 1000 Ω (1k) precision resistor. Then solder the connections and cut off the excess **capacitor** lead lengths.

(✓) R2/C3: Connect either resistor lead to wafer 1 lug 8 (NS) and the other lead to wafer 1 lug 11 (NS). Position the resistor/capacitor assembly between wafer 1 and the front mounting plate as shown.

(✓) Connect the free end of the 1-1/2" black wire from wafer 1 lug 5 to wafer 1 lug 8 (S-2).

(✓) Prepare a 1" bare wire from black wire.

(✓) Connect either end of the 1" bare wire to wafer 1 lug 11 (NS) and the other end to the metal plate (S-1).

(✓) Prepare a 2" black wire and connect either end to wafer 1 lug 11 (NS). The other end will be connected in a later step.

(✓) Prepare a 6" coaxial cable. Then connect either end to wafer 1: the inner lead to lug 10 (S-1) and the shield lead to lug 11 (S-4).

(✓) Remove label strip B78 from the number label and wrap it around the free end of the coaxial cable.

(✓) Prepare a 2-1/2" red wire and connect either end to wafer 3 lug 10 (S-1). The other end will be connected in a later step.

Carefully examine the switch for the following conditions.

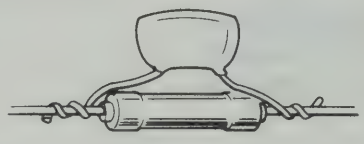
( ) No solder connections (wafer 3 lug 1 is not soldered at this time).

( ) "Cold" solder connections.

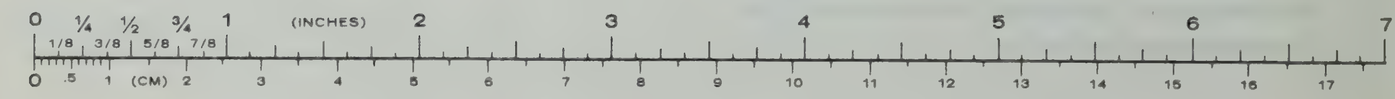
( ) Solder bridges between switch lugs.

( ) Component leads touching the switch frame, switch lugs, or other wires or leads.

Set the meter range switch aside temporarily.



Detail 7-2A



FREQUENCY RANGE SWITCH (SW3)

Refer to Pictorial 8-1 for the following steps.

☒ Position the frequency range switch (#63-1258) as shown in the Pictorial. Note that wafer 4 has no lugs on the side facing up.

NOTE: Wafers 2 and 3 have lugs on both the front and back. When you are instructed to connect leads or wires to double lugs on a wafer, the solder instruction will only count the leads or wires connected, not the number of lugs. Be sure to pass each lead or wire through both lugs and solder each lug to insure a good electrical contact.

☒ Locate the black sleeving and cut two 1″ lengths.

☒ Bend the leads of a 150 pF mica capacitor straight out, and place a 1″ black sleeve on each lead.

☒ C12: Connect either lead of the capacitor you prepared to wafer 1 lug 12 (NS) and the other lead to wafer 3 lug 1 (S-1).

☒ Prepare a 3-1/2″ black wire and connect either end to wafer 1 lug 12 (S-2). The other end will be connected in a later step.

NOTE: After you install each resistor, cut off the excess lead lengths.

☒ R24: Connect a 36 kΩ precision resistor from wafer 1 lug 11 (S-1) to wafer 2 lug 11 (NS).

☒ R22: Connect a 360 kΩ precision resistor from wafer 1 lug 10 (S-1) to wafer 2 lug 10 (NS).

☒ R20: Connect a 3.6 MΩ precision resistor from wafer 1 lug 9 (S-1) to wafer 2 lug 9 (NS).

☒ R18: Connect a 36 MΩ precision resistor from wafer 1 lug 8 (NS) to wafer 2 lug 8 (NS). NOTE: The resistor shape may be a flat body as shown, or a standard tubular body. Be very careful not to break the resistor lead bond on the flat body shape.

☒ R25: Connect a 36 MΩ precision resistor to wafer 1: from lug 8 (S-2) to lug 7 (S-1).

☒ R23: Connect a 4000 Ω (4 k) precision resistor from wafer 2 lug 11 (S-2) to wafer 3 lug 11 (NS).

☒ R21: Connect a 40 kΩ precision resistor from wafer 2 lug 10 (S-2) to wafer 3 lug 10 (NS).

☒ R19: Connect a 400 kΩ precision resistor from wafer 2 lug 9 (S-2) to wafer 3 lug 9 (NS).

☒ R17: Connect a 4 MΩ precision resistor from wafer 2 lug 8 (S-2) to wafer 3 lug 8 (NS).

☒ C13: Connect a 150 pF mica capacitor to wafer 3: from lug 11 (NS) to lug 12 (S-1). Position the capacitor inside the switch between wafer 3 and the metal plate, and away from the wafer 3 rotor.

☒ Prepare a 1-5/8″ bare wire from black wire.

NOTE: Where a wire passes through a connection and then goes to another point, as in the next step, it will count as two wires in the solder instructions (S-2), one entering and one leaving the connection. Be especially careful, when you solder these connections, to apply enough solder and heat to solder these "through wires."

☒ Connect the bare wire to wafer 3: from lug 11 (S-3), across lug 10 (S-3), across lug 9 (S-3), to lug 8 (NS). NOTE: Press the wire down against the resistor lead and over against the switch lug before you solder the connection at lugs 9 and 10.

☒ Prepare the following wires:

2-1/2″ black
2-3/4″ white
3-1/2″ red
3″ white

Connect either end of each wire to the frequency range switch as follows:

☒ 2-1/2″ black wire to wafer 3 lug 8 (S-3).

☒ 2-3/4″ white wire to wafer 3 lug 7 (S-1).

☒ 3-1/2″ red wire to wafer 5 lug 9 (S-1).

☒ Bend lug 7 on wafer 5 back over the wafer. Then connect the 3″ white wire to wafer 5 lug 7 (S-1).

Refer to Pictorial 8-2 for the following steps.

☒ Reposition the frequency range switch as shown in the Pictorial.

☒ Prepare a 3-1/4" red wire and connect either end to wafer 1 lug 6 (S-1).

NOTE: After you install each resistor, cut off the excess lead lengths.

☒ R15: Connect a 36 kΩ precision resistor from wafer 1 lug 5 (S-1) to wafer 2 lug 5 (NS).

☒ R13: Connect a 360 kΩ precision resistor from wafer 1 lug 4 (S-1) to wafer 2 lug 4 (NS).

☒ R11: Connect a 3.6 MΩ precision resistor from wafer 1 lug 3 (S-1) to wafer 2 lug 3 (NS).

NOTE: The next two resistors may have a flat body, as shown, or a standard tubular body.

☒ R9: Connect a 36 MΩ precision resistor from wafer 1 lug 2 (NS) to wafer 2 lug 2 (NS).

☒ R16: Connect a 36 MΩ precision resistor to wafer 1: from lug 2 (S-2) to lug 1 (S-1).

☒ R14: Connect a 4000 Ω (4 k) precision resistor from wafer 2 lug 5 (S-2) to wafer 3 lug 5 (NS).

☒ R12: Connect a 40 kΩ precision resistor from wafer 2 lug 4 (S-2) to wafer 3 lug 4 (NS).

☒ R10: Connect a 400 kΩ precision resistor from wafer 2 lug 3 (S-2) to wafer 3 lug 3 (NS).

☒ R8: Connect a 4 MΩ precision resistor from wafer 2 lug 2 (S-2) to wafer 3 lug 2 (NS).

☒ Prepare a 1-5/8" bare wire from black wire.

☒ Connect the bare wire to wafer 3: from lug 5 (NS), across lug 4 (S-3), across lug 3 (S-3), to lug 2 (NS).

NOTE: After you install each capacitor, cut off the excess lead lengths.

☒ C11: Connect a 0.0022 μF (2200 pF) Mylar capacitor from wafer 4 lug 5 (S-1) to wafer 5 lug 5 (NS). Position the capacitor body down between wafers 4 and 5.

☒ C10: Connect a 0.022 μF Mylar capacitor from wafer 4 lug 4 (S-1) to wafer 5 lug 4 (NS). Position the capacitor body down between wafers 4 and 5.

☒ C9: Connect a 0.22 μF Mylar capacitor from wafer 4 lug 3 (S-1) to wafer 5 lug 3 (NS). Position the capacitor body down between wafers 4 and 5, but away from the switch shaft.

☒ C8: Connect a 2.2 μF tantalum capacitor, the lead from the positive (+) or beveled end to **wafer 5 lug 2** (NS) and the other lead to wafer 4 lug 2 (S-1).

☒ C7: Connect a 4.7 μF tantalum capacitor, the lead from the positive (+) or red dot side to **wafer 5 lug 1** (NS) and the other lead to wafer 4 lug 1 (S-1). Position the capacitor body over against capacitor C8.

☒ Prepare a 2" bare wire from black wire.

☒ Connect the bare wire to wafer 5: from lug 5 (S-2), across lug 4 (S-3), across lug 3 (S-3), across lug 2 (NS), to lug 1 (S-2).

Refer to Pictorial 8-3 for the following steps.

(X) Unfold the frequency range switch wire harness (#134-966) as shown.

(X) If the wire ends are not pretinned, twist together the fine wire strands on each wire end. Then melt a small amount of solder on the wire ends to hold the fine wire strands together.

Connect the harness wires from breakouts 1, 2, and 3 to the switch in the following steps.

From breakout 1:

(X) Yellow wire to wafer 2 lug 6 (S-1).

(X) Green wire to wafer 2 lug 7 (S-1).

(X) White-gray wire to wafer 2 lugs 1 (S-1).

(X) White-brown wire under the capacitor lead to wafer 2 lug 12 (S-1). NOTE: Make sure the capacitor leads do not touch the switch frame or lugs 1 or 12 on wafer 2. Position the capacitor body over near wafer 2 lug 12.

From breakout 2:

(✓) Violet wire to wafer 3 lug 5 (S-3).

(X) Red wire to wafer 3 lug 2 (S-3).

(X) White-blue wire to wafer 4 lug 6 (S-1).

From breakout 3:

(X) White-black wire to wafer 5 lug 2 (S-4).

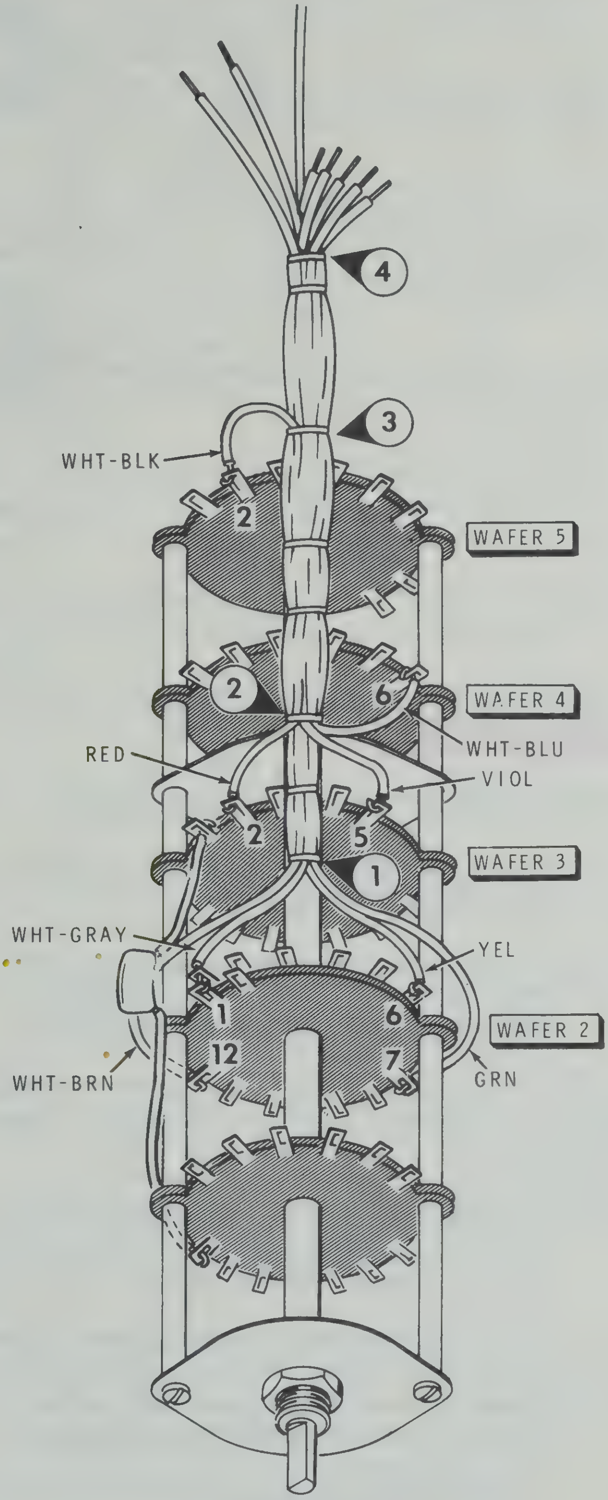
The wires from breakout 4 will be connected in later steps.

Carefully examine the switch for the following conditions:

( ) No solder connections.

( ) "Cold" solder connections.

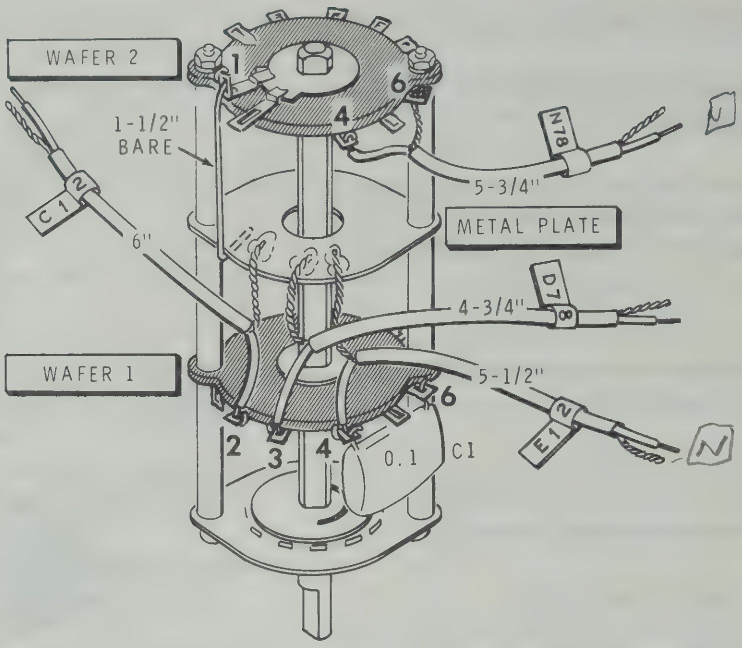
( ) Solder bridges between switch lugs.



PICTORIAL 8-3

( ) Component leads touching switch lugs, or other wires or leads.

Set the frequency range switch aside temporarily.



PICTORIAL 9-1

FUNCTION SWITCH

SW5

Refer to Pictorial 9-1 for the following steps.

B (✓) Position the Function switch (#63-1260) as shown in the Pictorial.

B (✓) C1: Connect a 0.1 μF Mylar capacitor to wafer 1: from lug 4 (NS) to lug 6 (S-1) Disregard any bands or polarity marks on the capacitor.

NOTE: When you connect a wire or lead to the metal plate on this switch, it will be considered a single solder step.

B (✓) Prepare a 1-1/2" bare wire from **white** wire and connect either end to wafer 2 lug 1 (NS) and the other end to the metal plate (S-1).

( ) Prepare the following coaxial cables. Then wrap a label strip, from the number label, around one end of each cable as indicated. NOTE: The labels are not in letter sequence.

6" coaxial cable — C12
4-3/4" coaxial cable — D78
5-1/2" coaxial cable — E12
5-3/4" coaxial cable — N78

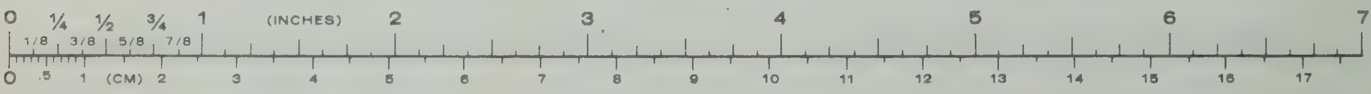
Connect the coaxial cables (the ends without the labels) to the Function switch in the following steps.

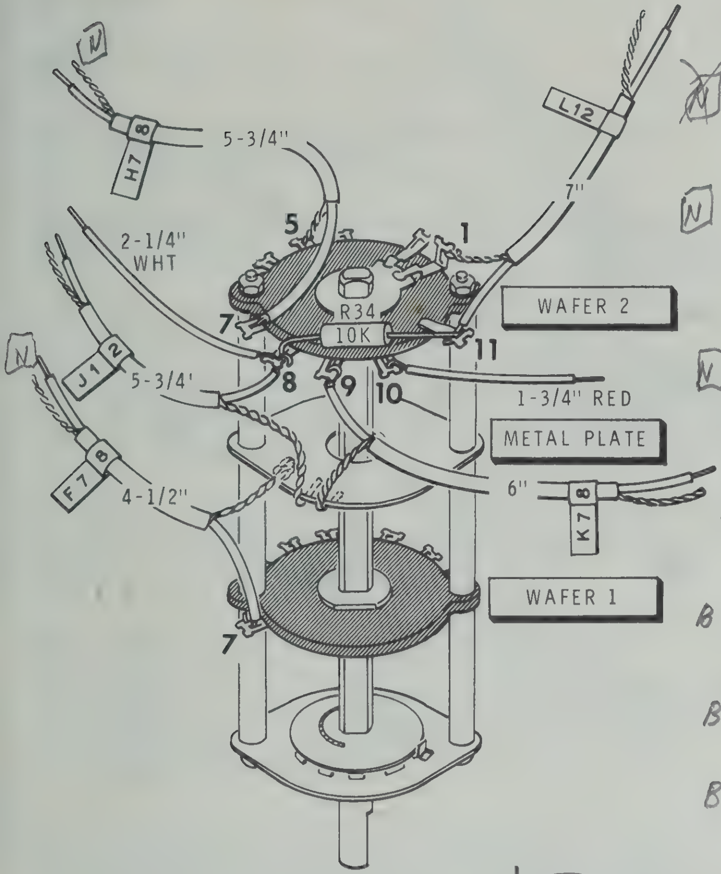
B (✓) 6" coaxial cable, C12: inner lead to wafer 1 lug 2 (S-1), and the shield lead to the metal plate (S-1).

B (✓) 4-3/4" coaxial cable, D78: inner lead to wafer 1 lug 3 (S-1), and the shield lead to the metal plate (S-1).

N (✓) 5-1/2" coaxial cable, E12: inner lead to wafer 1 lug 4 (S-2), and the shield lead to the metal plate (S-1)

N (✓) 5-3/4" coaxial cable. N78, to wafer 2: inner lead to lug 4 (S-1) and the shield lead to lug 6 (S-1).





PICTORIAL 9-2

SW5

Refer to Pictorial 9-2 for the following steps.

B(✓) Reposition the Function switch as shown.

(✓) Prepare the following coaxial cables. Then wrap a label strip, from the number label, around one end of each cable as indicated.

4-1/2" coaxial cable — F78
5-3/4" coaxial cable — H78
5-3/4" coaxial cable — J12
6" coaxial cable — K78
7" coaxial cable — L12

Connect the coaxial cables (the ends without the labels) to the Function switch in the following steps.

N (✓) 4-1/2" coaxial cable, F78: inner lead to wafer 1 lug 7 (S-1) and the shield lead to the metal plate (S-1).

N (✓) 5-3/4" coaxial cable, H78: remove an extra 1/2" length of outer insulation from the end without the identification label. Then, at the same end, cut the shield lead to 3/8".

N (✓) 5-3/4" coaxial cable, H78, to wafer 2: inner lead to lug 7 (S-1), and the shield lead to lug 5 (S-1).

(✓) 5-3/4" coaxial cable, J12: inner lead to wafer 2 lug 8 (NS) and the shield lead to the metal plate (S-1).
B

B (✓) 6" coaxial cable, K78: inner lead to wafer 2 lug 9 (S-1) and the shield lead to the metal plate (S-1).

B (✓) 7" coaxial cable, L12 to wafer 2: the inner lead to lug 11 (NS) and the shield lead to lug 1 (S-2).

B (✓) R34: Connect a 10 kΩ (brown-black-orange) resistor to wafer 2; from lug 8 (NS) to lug 11 (S-2).

B (✓) Prepare a 2-1/4" white wire and connect either end to wafer 2 lug 8 (S-3).

B (✓) Prepare a 1-3/4" red wire and connect either end to wafer 2 lug 10 (S-1).

Carefully examine the switch for the following conditions.

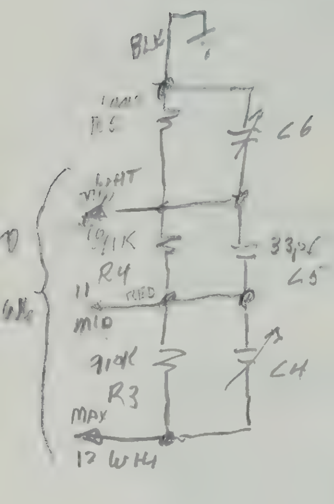
( ) No solder connections. There are no wires connected to wafer 1 lugs 1 and 5, or wafer 2 lug 2.

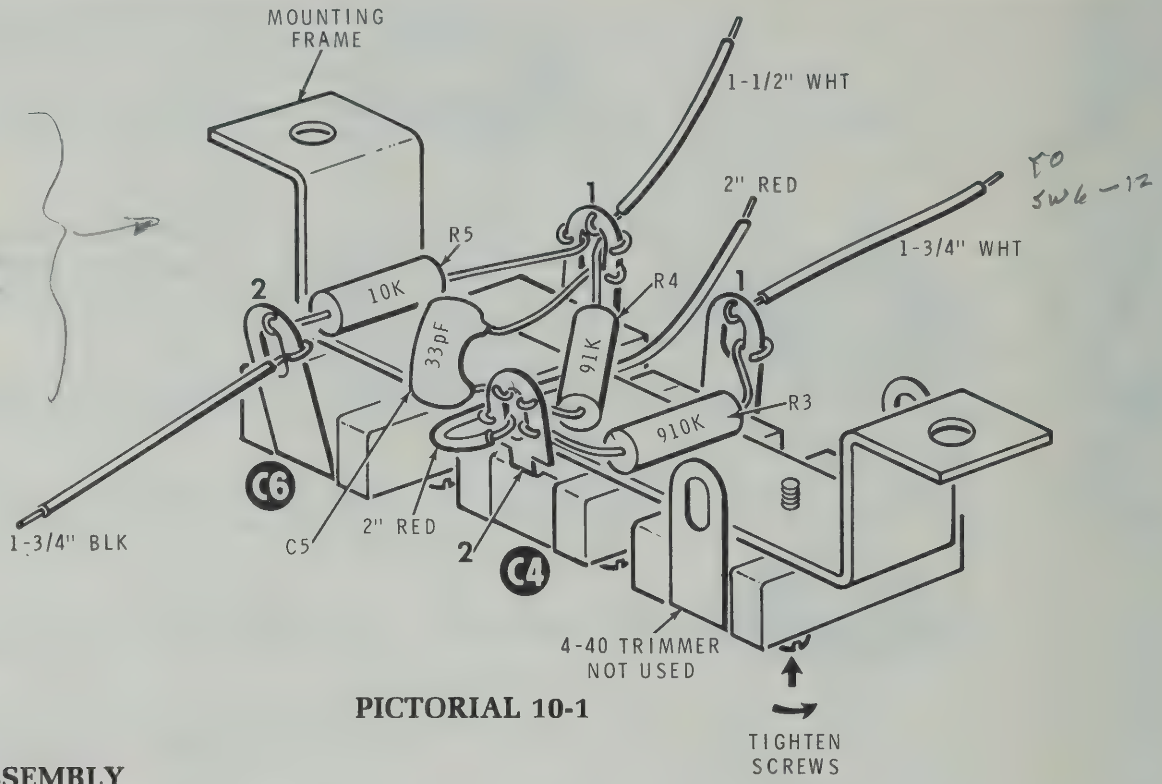
( ) "Cold" solder connections.

( ) Solder bridges between switch lugs.

( ) Component leads touching the switch frame, switch lugs, or other wires or leads.

Set the Function switch aside temporarily.





PICTORIAL 10-1

TRIMMER ASSEMBLY

Refer to Pictorial 10-1 for the following steps.

(✗) Turn the three adjust screws on the 40/20/700 pF 3-section trimmer (#31-70) clockwise until they are snug.

(✓) Position the trimmer as shown in the Pictorial.

NOTE: When you mount resistors to this trimmer assembly, position the resistor bodies down next to the mounting frame.

(✓) R5: Connect a 10 kΩ (brown-black-orange) resistor between lugs 1 (NS) and 2 (NS) of the 700 pF trimmer (C6).

(✓) Prepare a 1-3/4″ black wire and connect either end to trimmer C6 lug 2 (S-2).

( ) R4: Connect a 91 kΩ (white-brown-orange) resistor from trimmer C6 lug 1 (NS) to trimmer C4 lug 2 (NS).

( ) C5: Connect a 33 pF mica capacitor from trimmer C6 lug 1 (NS) to trimmer C4 lug 2 (NS). Route the capacitor leads as shown, and position the capacitor body over the adjust screw of trimmer C6.

(✗) Prepare a 1-1/2″ white wire and connect either end to trimmer C6 lug 1 (S-4).

( ) R3: Connect a 910 kΩ (white-brown-yellow) resistor to trimmer C4 from lug 1 (NS) to lug 2 (NS).

(✗) Prepare a 2″ red wire and connect either end to trimmer C4 lug 2 (S-4). Route the wire as shown.

(✗) Prepare a 1-3/4″ white wire and connect either end to trimmer C4 lug 1 (S-2).

(✗) Resolder trimmer C6, lugs 1 and 2, to make sure all of the lug "leaves" are soldered together.

(✗) Carefully compare the 3-section trimmer assembly with Pictorial 10-1 and make sure all of the components are properly mounted and soldered. This will be difficult to check after the assembly is mounted to the chassis.

Set the trimmer assembly aside temporarily.

CHASSIS

Refer to Pictorial 11-1.

(✓) Position the chassis as shown in the Pictorial, with the **bottom side up.**

NOTE: Use the plastic nut starter to hold and start 6-32 and 4-40 nuts on screws.

(X) Mount the rear panel to the chassis with three 6-32 × 3/8" black screws, three #6 lockwashers, and three 6-32 nuts. Position the rear panel so the large hole for the line cord is visible when the panel is mounted.

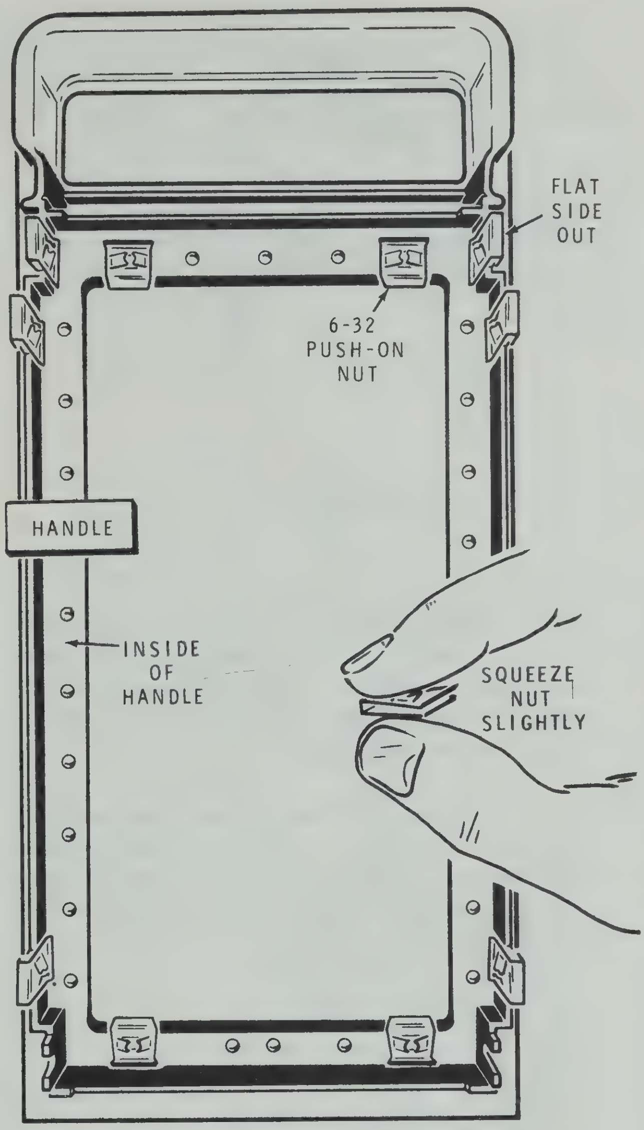
NOTE: Place a cloth or small rug on your work surface to avoid scratching the two black handles you will install in the following steps.

(✓) Refer to Detail 11-1A and install ten 6-32 push-on nuts onto **each** handle. Squeeze each nut slightly so that it will fit securely onto the handle. Position the flat side of the nut to the **outside** of the handle.

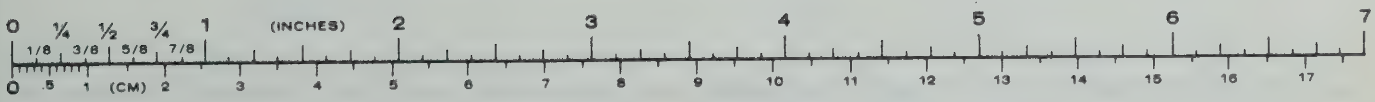
(X) Mount either handle to the left side of the chassis with a 6-32 × 3/8" black flat head screw, a #6 lockwasher, and a 6-32 nut. Do not tighten the hardware.

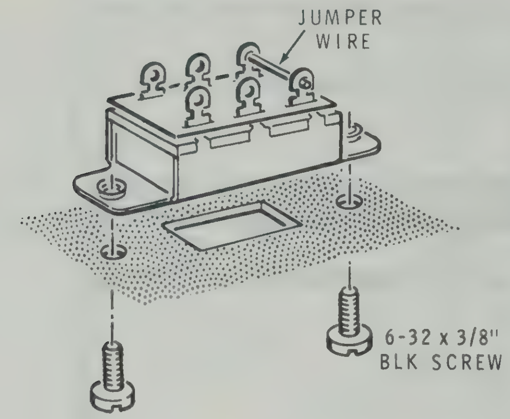
(X) Secure the handle to the rear panel with two 6-32 × 3/8" black screws. Then tighten the flat head screw that secures the handle to the chassis.

(X) In a like manner, mount the other handle to the chassis with a 6-32 × 3/8" black flat head screw, a #6 lockwasher, and a 6-32 nut, and to the rear panel with two 6-32 × 3/8" black screws.

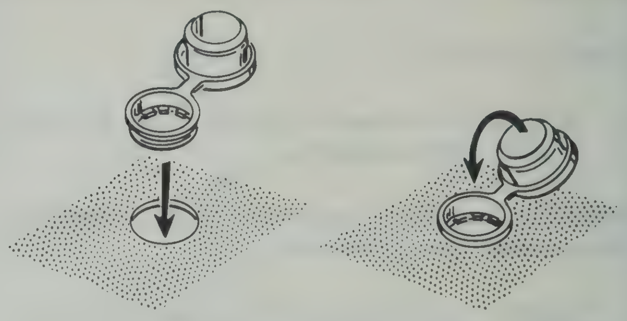


Detail 11-1A





Detail 11-1B



POSITION THE SMALL PORTION OF THE GROMMET INTO THE CHASSIS HOLE.

BEND THE LARGE PORTION OF THE GROMMET OVER AND INTO THE SMALL PORTION. PRESS IT FIRMLY INTO PLACE.

Detail 11-1D

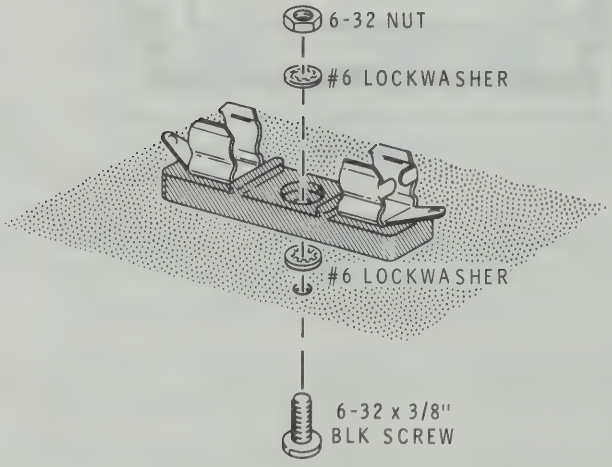
( ) SW1: Refer to Detail 11-1B and mount the slide switch to the inside of the rear panel at location SW1 with two 6-32 × 3/8" black screws. Position the jumper wire on the switch toward the right side of the panel.

(✓) Refer to Detail 11-1C and mount the fuse block at location A2 with a 6-32 × 3/8" black screw, two #6 lockwashers, and a 6-32 nut. Position the fuse block parallel with the chassis.

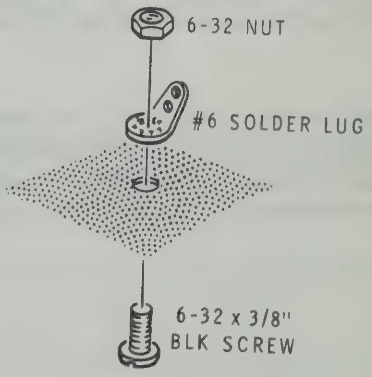
( ) Refer to Detail 11-1D and install plastic grommets at holes B1, B2, B3, B4, and B5.

(✓) Refer to Detail 11-1E and install a #6 solder lug at hole B6 with a 6-32 × 3/8" black screw and 6-32 nut. Position the solder lug as shown in the Pictorial.

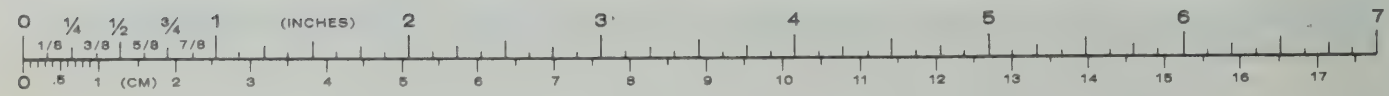
(✓) In a like manner, mount a #6 solder lug to the TOP side of the chassis at location B7 with a 6-32 × 3/8" black screw and 6-32 nut. Position the solder lug as shown.



Detail 11-1C



Detail 11-1E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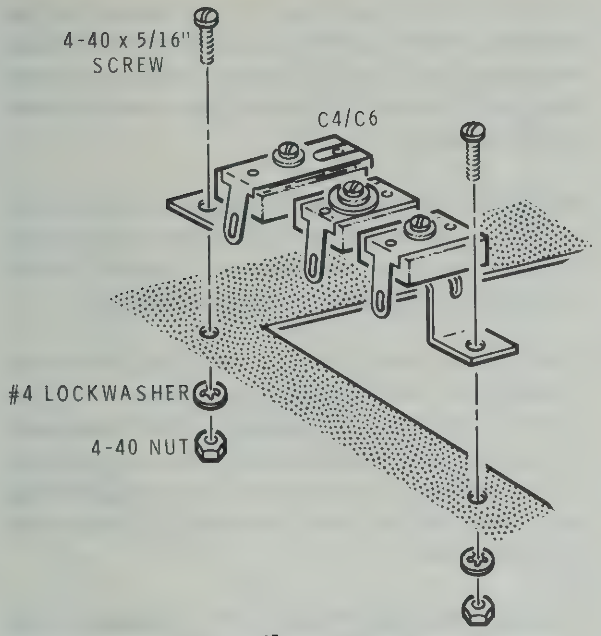
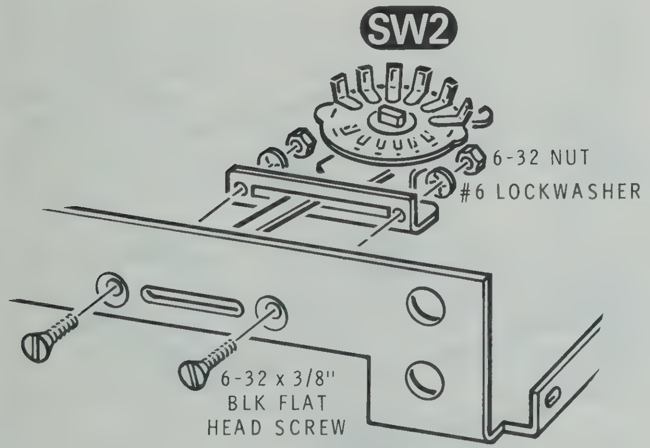
1/8 3/8 5/8 7/8
0 .5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



Detail 11-1F

(X) Refer to Detail 11-1F and mount the trimmer assembly to the chassis at location B8 with two 4-40 × 5/16" screws, two #4 lockwashers, and two 4-40 nuts. Be sure to position the two small trimmers toward the front of the chassis.

(✓) SW2: Refer to Detail 11-1G and mount the mode switch (#62-41) to the front of the chassis with two 6-32 × 3/8" black flat head screws, two #6 lockwashers, and two 6-32 nuts. Hold the switch down toward the chassis as you tighten the screws, so the switch lever will be parallel to the front panel slot when the panel is installed later.

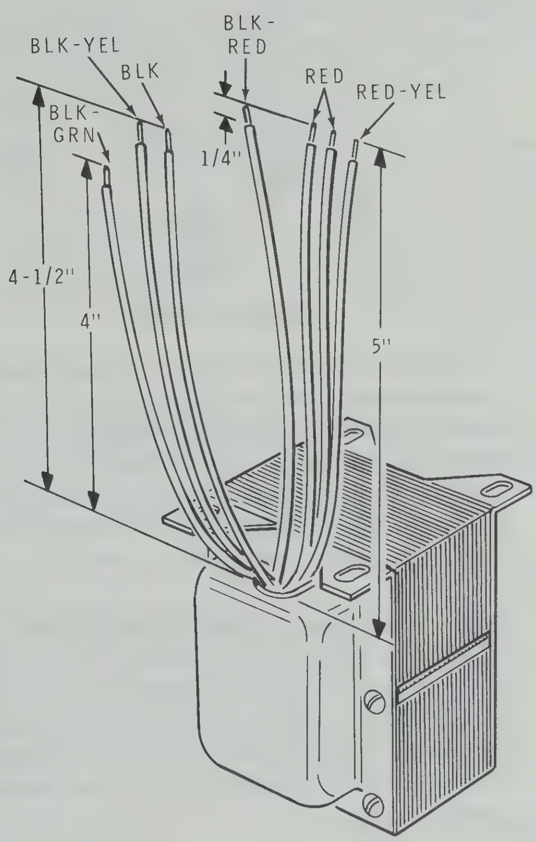


Detail 11-1G

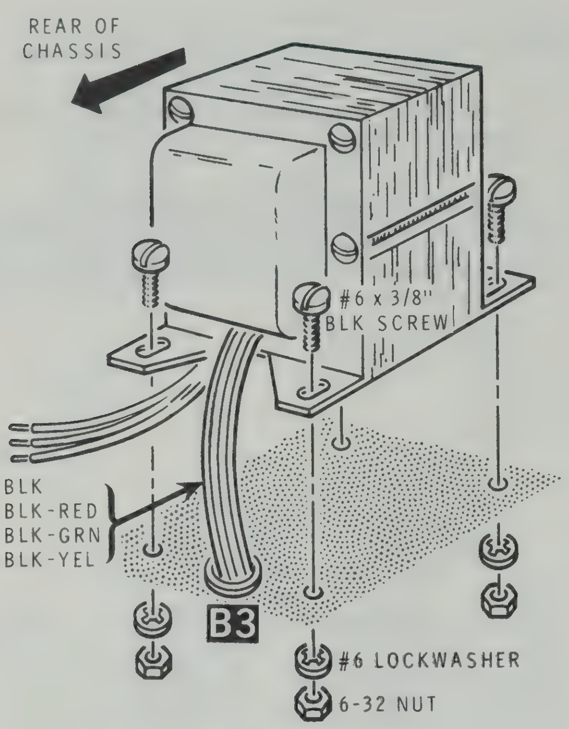
Refer to Pictorial 11-2 for the following steps.

(✓) Reposition the chassis assembly as shown in the Pictorial.

(✓) Refer to Detail 11-2A and prepare the power transformer leads. Cut each lead to the indicated length and remove 1/4" of insulation from each lead.



Detail 11-2A



Detail 11-2B

( ) T1: Refer to Detail 11-2B and mount the power transformer to the chassis with four 6-32 × 3/8" black screws, four #6 lockwashers, and four 6-32 nuts. Pass only the black, black-green, black-yellow, and black-red leads through grommet B3. Position the remaining leads toward the center rear of the chassis.

( ) Mount the power supply circuit board to the chassis as shown, with three 4-40 × 5/16" screws, three #4 lockwashers, and three 4-40 nuts. Install the hardware at the three mounting holes indicated by arrows. Do not pinch the bare circuit board wire between the chassis and circuit board.

( ) Mount a #4 solder lug to the **bottom** of the chassis at the fourth power supply mounting hole with a 4-40 × 5/16" screw and 4-40 nut. Position the solder lug toward the power transformer as shown.

( ) Mount the auto null circuit board to the chassis as shown with three 4-40 × 5/16" screws, three #4 lockwashers, and three 4-40 nuts. Install the hardware at the three mounting holes indicated by arrows. Do not pinch the bare circuit board wire between the chassis and circuit board.

( ) Mount a #4 solder lug to the **bottom** of the chassis at the fourth auto null circuit board mounting hole with a 4-40 × 5/16" screw and 4-40 nut. Position the solder lug toward the rear panel as shown.

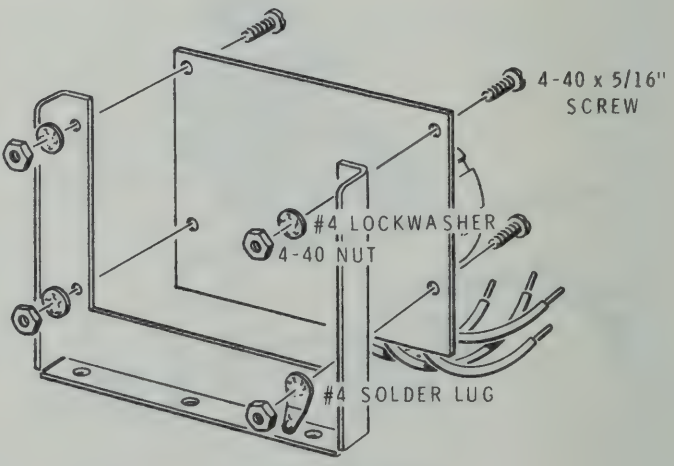
( ) Route the auto null wire harness over the chassis as shown. Then insert all of the loose wires, at the free end (except the coaxial cable), through the chassis opening as shown.

( ) Mount the meter amplifier circuit board to the chassis as shown with three 4-40 × 5/16" screws, three #4 lockwashers, and three 4-40 nuts. Install the hardware at the three mounting holes indicated by arrows. Do not pinch the bare circuit board wire between the chassis and circuit board.

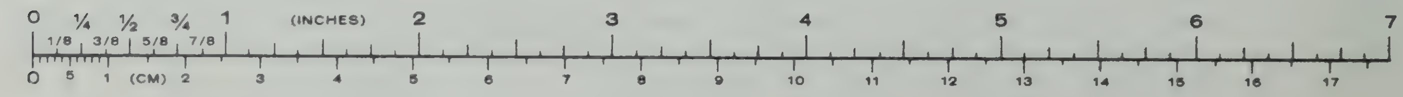
( ) Mount a #4 solder lug to the **bottom** of the chassis at the fourth meter amplifier mounting hole with a 4-40 × 5/16" screw and 4-40 nut. Position the solder lug toward the front of the chassis as shown.

( ) Refer to Detail 11-2C and mount the optical isolator circuit board to the circuit board mounting bracket with four 4-40 × 5/16" screws, three #4 lockwashers, one #4 solder lug, and four 4-40 nuts. Position the solder lug as shown.

( ) Position the bridge amplifier circuit board on the chassis, with the component side down, as shown.



Detail 11-2C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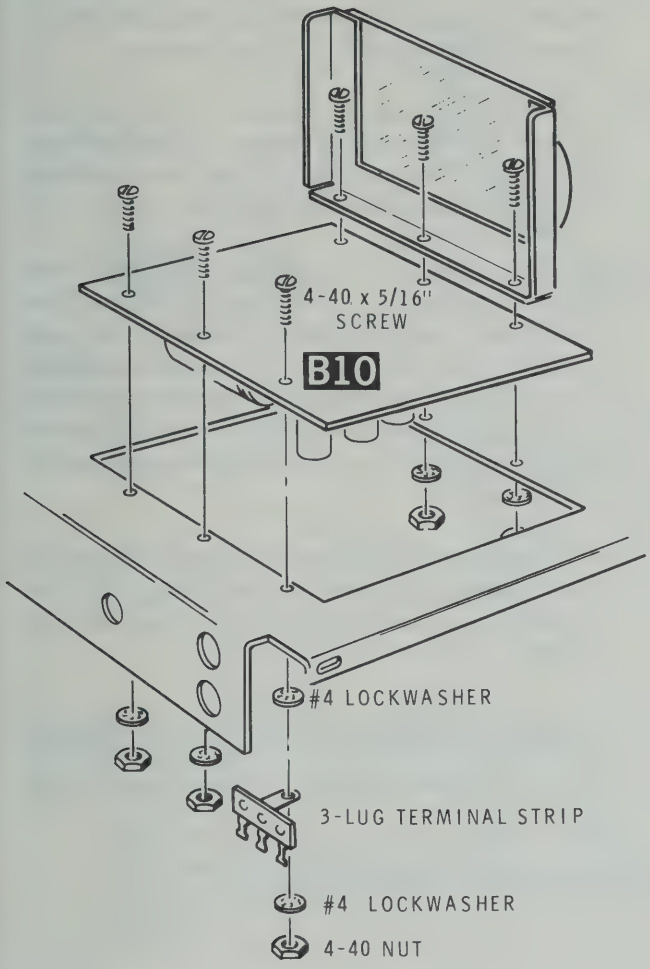
1/8 3/8 5/8 7/8
0 5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



Detail 11-2D

☒ Refer to Detail 11-2D and loosely mount the optical isolator circuit board bracket to the bridge amplifier circuit board and the chassis with three 4-40 × 5/16" screws, three #4 lockwashers, and three 4-40 nuts. Do not pinch any auto null harness wires under the circuit board.

☒ Refer to Detail 11-2D and mount a 3-lug terminal strip to the bottom of the chassis at hole B10 with a 4-40 × 5/16" screw, two #4 lockwashers, and a 4-40 nut. Position the terminal strip as shown.

☒ Secure the bridge amplifier circuit to the chassis at the two remaining holes with two 4-40 × 5/16" screws, two #4 lockwashers, and two 4-40 nuts. Then tighten the four loose circuit board mounting screws.

☒ Mount the null amplifier circuit board to the right handle with two 6-32 × 3/8" black flat head screws, two #6 lockwashers, two #6 washers and two 6-32 nuts. Position the circuit board on the inside of the handle, and in line with the bridge amplifier circuit board. Insert the #6 washers between the circuit board and handle.

☒ Connect the white wire from hole F on the optical isolator circuit board to hole AA (S-1) on the null amplifier circuit board.

☒ Connect the coaxial cable from breakout 4 of the auto null wire harness to the null amplifier circuit board: inner lead to hole CC (S-1) and the shield lead to hole DD (S-1).

☒ Prepare a 7" coaxial cable. Then from either end, connect the inner lead to hole EE (S-1) and the shield lead to hole HH (S-1) on the null amplifier circuit board. Pass the free end of the cable through hole C on the bridge amplifier circuit board; it will be connected in a later step.

☒ Cut off any excess wire ends.

☒ Remove 9" of insulation from one end of the white hookup wire. This wire will be used to interconnect the bridge amplifier circuit board and null amplifier circuit board.

NOTE: When you interconnect the bridge and null amplifiers, pass the bare wire through the indicated hole in the null amplifier circuit board. Then push the wire end into the indicated hole in the bridge amplifier circuit board about 1/8". Solder the wire to the two circuit boards and cut off the free end. Refer to Detail 11-2E for the wire locations.

Interconnect the bridge and null amplifier circuit boards as follows:

☒ Bare wire from hole H (S-1) to hole H (S-1).

☒ Bare wire from hole G (S-1) to hole G (S-1).

☒ Bare wire from hole GG (S-1) to hole F (S-1).

☒ Bare wire from hole E (S-1) to hole E (S-1).

☒ Bare wire from hole D (S-1) to hole D (S-1).

☒ Bare wire from hole B (S-1) to hole B (S-1).

☒ Bare wire from hole A (S-1) to hole A (S-1).

( ) Refer to Detail 11-2E and connect the bare wire from the bridge amplifier circuit board to the solder lug on the optical isolator circuit board (NS).

( ) Prepare a 1" bare wire from the white wire. Then refer to Detail 11-2E and connect either end to hole K (S-1) on the optical isolator circuit board. Connect the free end to the solder lug (S-2).

( ) C111: Refer to Detail 11-2E and connect either lead from a 0.047 μF Mylar capacitor to hole M (S-1) on the bridge amplifier circuit board, and the other lead to hole BB (S-1) on the null amplifier circuit board. Cut off any excess lead lengths. NOTE: Disregard any bands or polarity marks on the capacitor.

( ) Locate the 420 pF-420 pF variable, 2-section capacitor and examine the plates. They should be straight and free of any small pieces of metal, which could short the plates together. Turn the shaft fully counterclockwise (to protect the plates).

( ) C118/C119: Refer to Detail 11-2F and mount the variable capacitor to the bridge amplifier circuit board with three 6-32 × 3/16" screws.

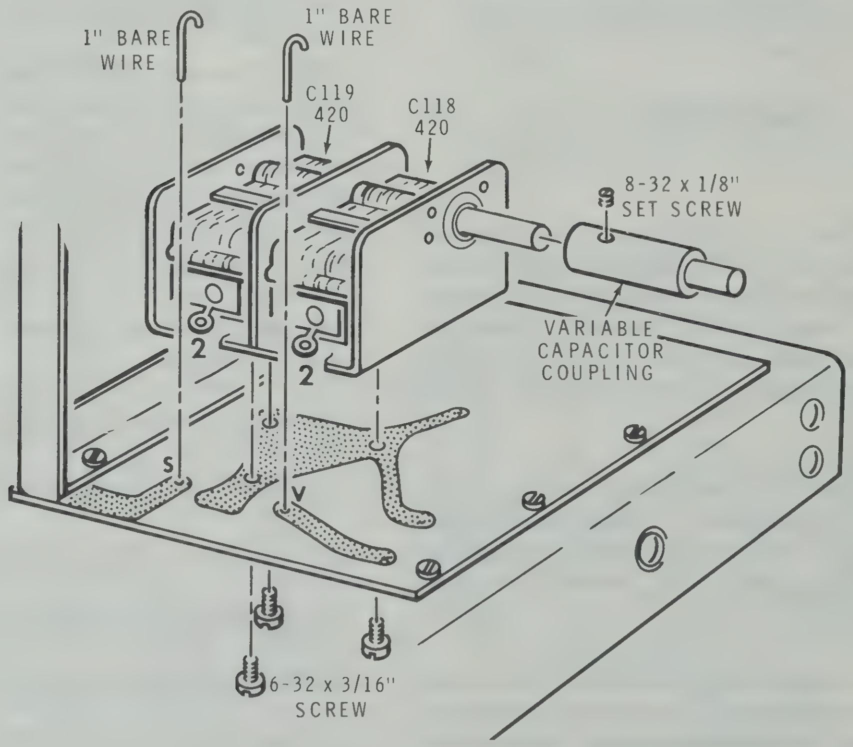
( ) Locate the variable capacitor coupling and press it onto the variable capacitor shaft as far as it will go. Then secure it to the shaft with an 8-32 × 1/8" set screw as shown in Detail 11-2F.

( ) Refer to Detail 11-2F, prepare a 1" bare wire from white wire, and form a 1/8" loop in one end. Then pass the straight end of the wire through hole S (S-1) in the bridge amplifier circuit board, and hook the loop through lug 2 (S-1) of variable capacitor C119. Cut off the excess wire length from the component side of the circuit board.

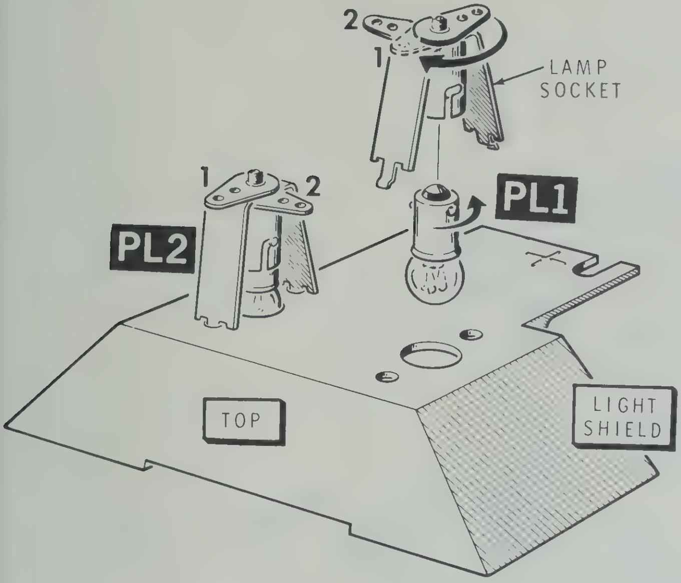
( ) In a like manner, prepare a second 1" bare wire and connect it from hole V (S-1) to lug 2 (S-1) of variable capacitor C118. Cut off the excess wire length.

( ) Mount the shield bracket (#204-2142) to the top of the chassis at B12, with two 6-32 × 3/8" black screws, two #6 lockwashers, and two 6-32 nuts (Pictorial 11-2).

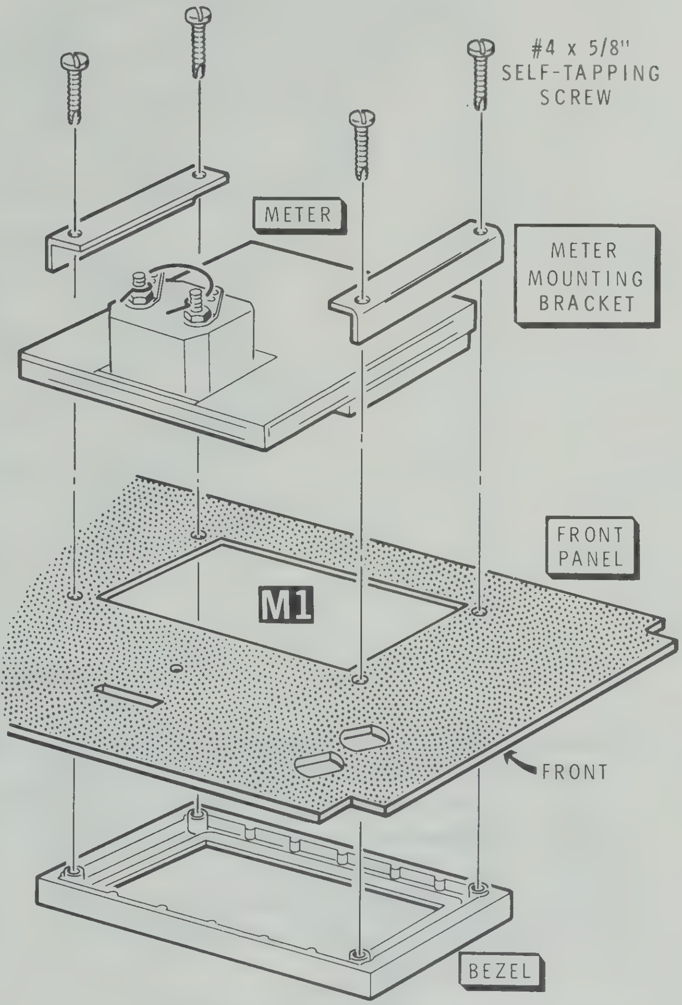
Set the chassis aside temporarily.



Detail 11-2F



Detail 11-3A



Detail 11-3B

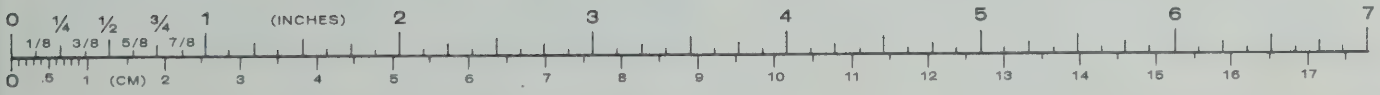
Refer to Pictorial 11-3 for the following steps.

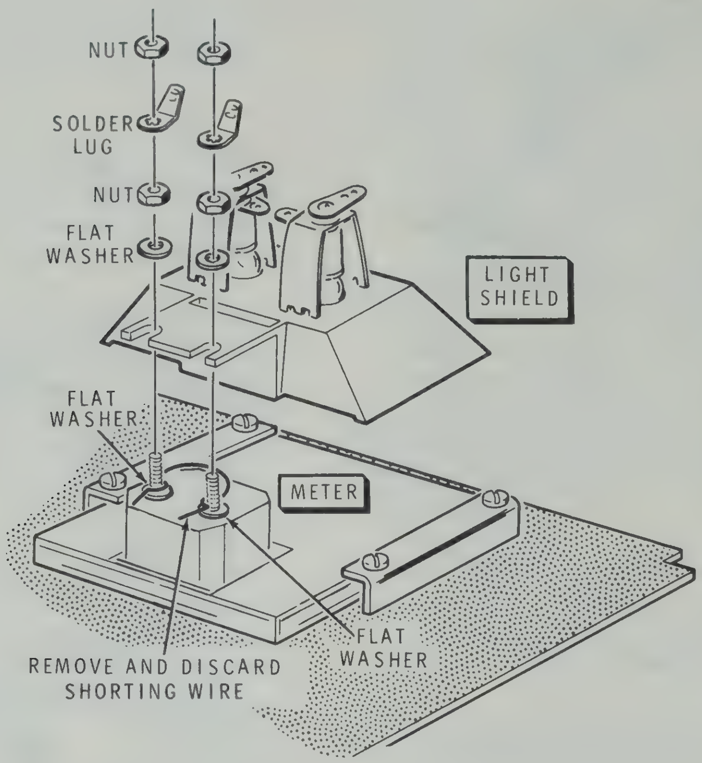
(✓) PL1/PL2: Refer to Detail 11-3A and insert a lamp into each lamp socket. Then mount the two sockets to the light shield. Make sure lug 2 of each socket is toward the center of the light shield.

(✗) Refer to Detail 11-3A and grasp lug 1 of socket PL1 with a pair of long-nose pliers. Then carefully rotate the lug until it is positioned toward the top of the light shield.

(✗) Position the front panel as shown in the Pictorial.

(✓) M1: Refer to Detail 11-3B and loosely mount the meter to the front panel at hole M1 with the meter bezel, two meter mounting brackets, and four #4 × 5/8" self-tapping screws.





Detail 11-3C

( ) Remove the meter shorting wire and loosen the two nuts on each meter binding post. Then refer to Detail 11-3C and install the light shield on the meter between the two flat washers on each binding post. Tighten the inner nut on each binding post. If you have a nut driver, remove the two outer nuts and two solder lugs for access to the inner nuts.

( ) Position the solder lug on each binding post as shown, and tighten the outer nut on each binding post.

( ) Tighten the four meter mounting screws. The light shield should fit between the screws, against the meter mounting brackets. CAUTION: Do not overtighten the screws and damage the bezel.

( ) Loosely mount the variable capacitor reduction drive to the inside of the front panel at hole C1 with two 4-40 × 5/16" screws, two #4 lockwashers, and two 4-40 nuts.

( ) Loosen the two set screws in the reduction drive.

Refer to Pictorial 11-4 for the following steps.

(X) Position the chassis on its right side as shown.

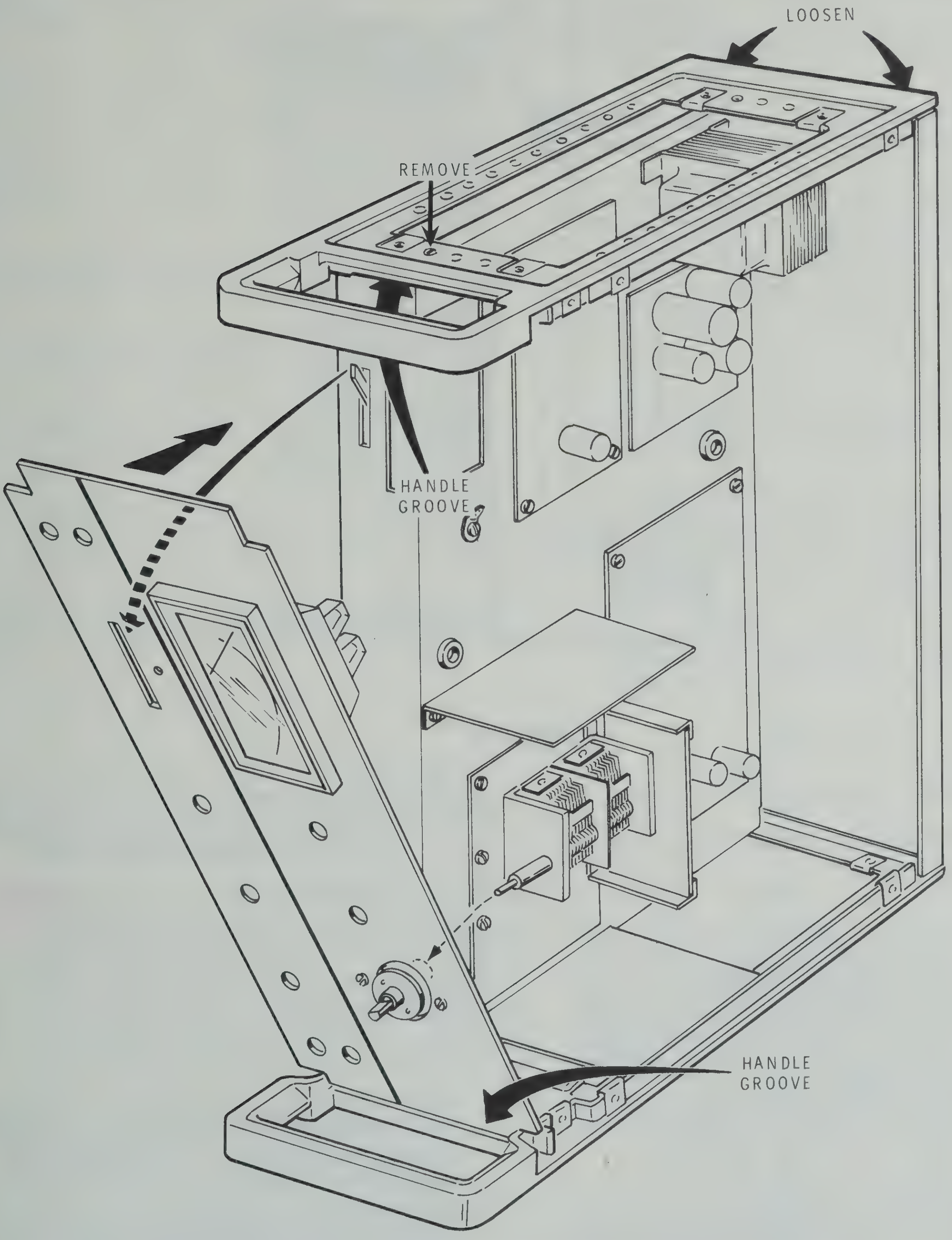
(✓) Remove the black flat head screw, lockwasher, and nut that secures the left handle to the chassis. Then loosen the two screws that secure the left handle to the rear panel.

(X) Position the front panel into the groove in the right handle as shown.

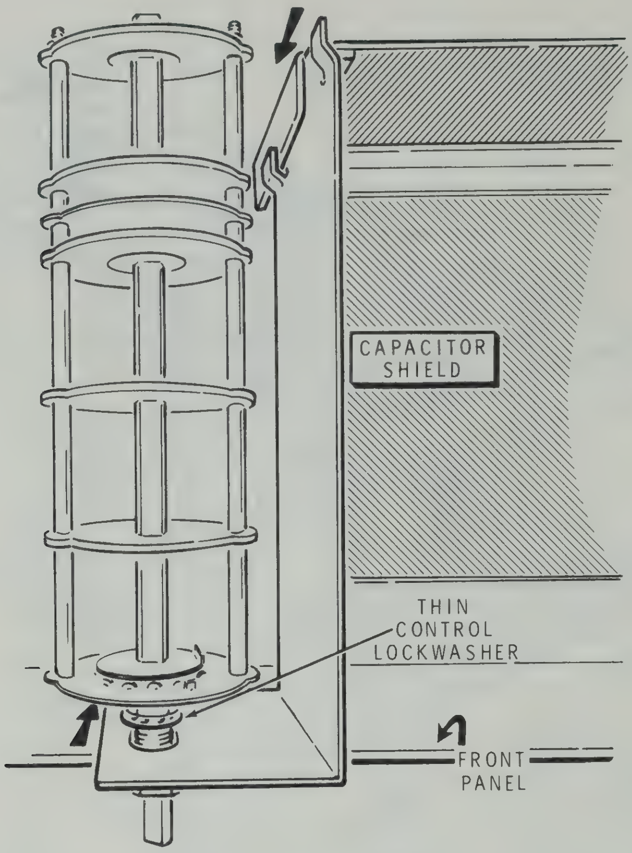
( ) Lift the left handle up, fit the reduction drive over the variable capacitor coupling, fit the Mode switch lever into the front panel slot, and swing the front panel into the groove in the left handle.

( ) Retighten the two rear panel screws. Then secure the handle to the chassis with the black flat head screw, lockwasher, and nut you previously removed.

NOTE The front panel may have a slight bow in it. This is normal. When the remaining parts are mounted to it, the bow will be removed.



PICTORIAL 11-4



Detail 11-5A

Refer to Pictorial 11-5 for the following steps.

(✓) Position the chassis as shown in the Pictorial.

(✓) SW3: Place a thin control lockwasher on the shaft of the frequency range switch. Then mount the switch to the front panel at SW3 with a control flat washer and control nut. Position the switch so the wire harness is on top. Route the six loose wires as follows: red and white from wafer 5, straight back; white and black from wafer 3, to the right; red and black (under the switch) from wafer 1, to the right.

Connect the four wires on the right side of the frequency range switch to the bridge amplifier circuit board as follows:

(✓) Black wire from wafer 3 to hole W (S-1). Position the wire so the insulation is 1/8" from the foil. NOTE: The letter W is not etched on the circuit board.

(✓) White wire from wafer 3 to hole T (S-1). Disregard any solder bridge that may form between the wire and the variable capacitor frame.

(✓) Black wire from wafer 1 to hole X (S-1).

(✓) Red wire from wafer 1 to hole Y (S-1).

(✓) Press the four wires down against the circuit board and chassis.

(✓) Loosen the frequency range switch control nut.

(✓) Refer to Detail 11-5A and slide the capacitor shield down onto the chassis so the rear locating tabs engage the edge of the optical isolator circuit board mounting bracket, and the front notch fits over the frequency range switch shaft, between the lockwasher and front panel. When the capacitor shield is in position, there is sufficient space beneath the shield to clear the four switch wires. However, make sure the bare lead of each wire does not come into contact with the shield.

( ) Tighten the switch control nut.

Connect the two loose wires from wafer 5 to the auto null amplifier circuit board as follows:

(✓) Red wire to hole N (S-1).

(✓) White wire to hole U (S-1).

Connect the frequency range switch harness wires as follows:

(✓) White-black wire to hole S (S-1) on the auto null amplifier circuit board.

(✓) White-blue wire to hole R (S-1) on the auto null amplifier circuit board.

(✓) Violet wire to hole FF (S-1) on the null amplifier circuit board.

(✓) Spread apart the remaining five wires so their ends do not touch. They will be connected in "Final Assembly."

Connect three wires from the optical isolator circuit board to the auto null amplifier circuit board as follows:

(✓) White wire from hole J to hole P (S-1).

(✓) Red (short) wire from hole H to hole M (S-1).

(✓) Red (long) wire from hole G to hole D (S-1). Route this wire as shown.

(✓) SW4: Place a thick control lockwasher on the shaft of the meter range switch. Then mount the switch to the front panel at SW4 with a control flat washer and control nut. As you install the switch, pass the two coaxial cables through grommet B5. Position the switch so the trimmer capacitor is up.
B

Connect the switch wires as follows:

(✓) Short black wire to solder lug B7 (NS).

(✓) Pass the long black wire under the switch to solder lug B7 (S-2).

(✓) Red wire to the meter amplifier circuit board hole A (S-1).

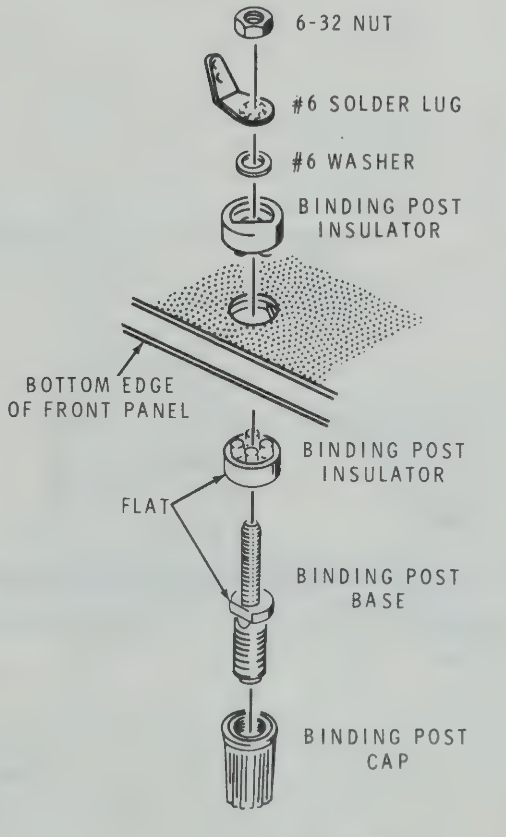
(✓) Connect the inner lead of the coaxial cable, from breakout 1 of the auto null wire harness, to switch SW4, wafer 3 lug 1 (S-2). There is no shield lead.

Refer to Pictorial 11-6 for the following steps.

(✓) Position the chassis bottom side up as shown in the Pictorial.

(✓) Refer to Detail 11-6A and install a red binding post assembly at hole CA as follows:

1. Press a red binding post insulator into the hole from each side of the front panel. The flat on the outside insulator should be either parallel with, or vertical to, the bottom edge of the front panel. Align each binding post you install in the same manner.
2. Insert the binding post base into the two insulators from the front.
3. Place a #6 washer and a #6 solder lug over the small threads on the binding post base. Then secure the washer and solder lug with a 6-32 nut. NOTE: Position the solder lug toward the center of the chassis.
4. Screw a red binding post cap onto the binding post base.



Detail 11-6A

HEATH
Schlumberger

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

November 9, 1977

IMPORTANT NOTICE

Please make the following changes in your Manual before you start to assemble your kit.

Page 54 — Right column, third step. Change the second sentence . . .

From: "Then mount the switch to the front panel at SW5 with a control flat washer and a control nut."

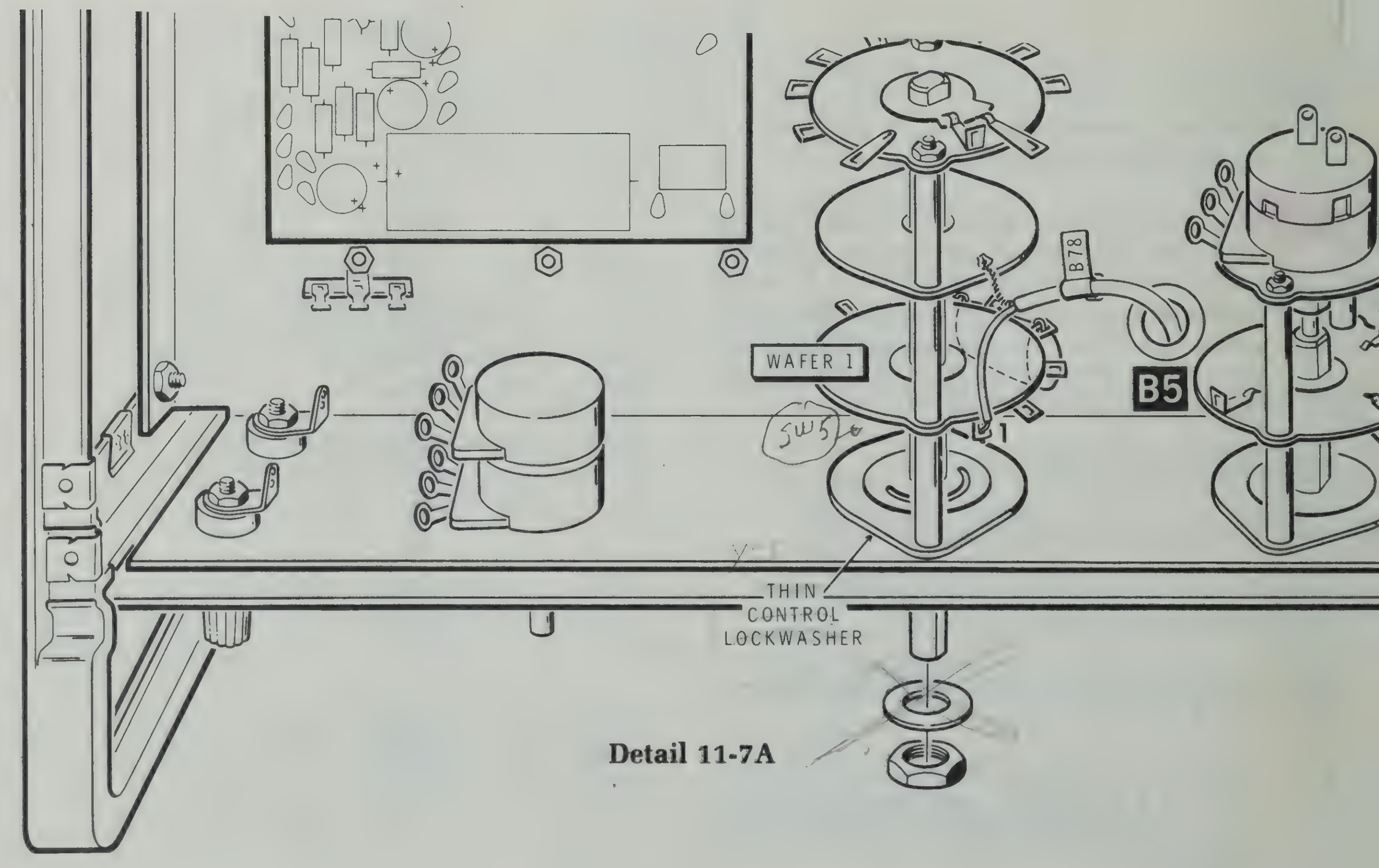
To: "Then mount the switch to the front panel at SW5 with a control nut." (Delete ". . . a control flat washer and . . .").

— Detail 11-7A. Locate the control flat washer and the control nut shown at the bottom of the Detail. Delete the control flat washer; it will not be used.

Thank you,

HEATH COMPANY

IM-5258/595-1842-02
591-2494



Detail 11-7A

B (X) Loosen the control nut and turn switch SW5 clockwise, so coaxial cable B78 is pulled under the switch, and the switch is positioned as shown in the Pictorial. Tighten the control nut. Then examine lug 1 on wafer 1 to make sure it does not touch the chassis. CAUTION: Loosen the switch enough, so the wafer lugs do not rub against the chassis as you turn the switch.

B (/) Connect the inner lead of coaxial cable A12, from grommet B5, to switch SW5 wafer 1 lug 5 (S-1). Then solder the shield lead to the metal plate.

Connect the coaxial cables from switch SW5 as follows:

B SW5 - W1 L2 INNER
PLATE - SHLD

B (X) Cable C12 to the bridge amplifier circuit board: inner lead to hole P (S-1) and shield lead to hole Z (S-1).

B SW5 W2 L8 INNER
PLATE - SHLD

B (X) Cable J12 to the bridge amplifier circuit board: inner lead to hole N (S-1). Cut off the shield lead at the cable insulation.

B SW5 W2 L9 INNER
PLATE - SHLD

B (+) Cable K78 to the bridge amplifier circuit board: inner lead to hole L (S-1). Cut off the shield lead at the cable insulation.

N SW5 W1 L4 INNER
PLATE - SHLD

B (+) Cable E12: inner lead to red binding post lug CC (S-1), shield lead to black binding post lug CD (NS). Route the cable under control R6/R7, near the chassis.

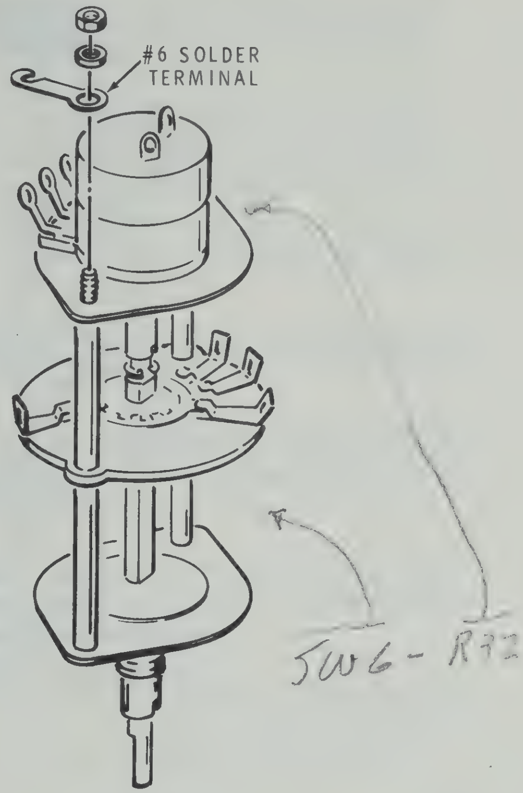
OK (/) Prepare a 1-1/2" black wire and connect either end to black binding post CD (S-2). Then connect the other end to terminal strip B10 lug 2 (S-1).

N SW5 W2 L4 - INNER
W2 L6 - SHLD

B (X) Cable N78 to terminal strip B10: inner lead to lug 3 (S-2), and shield lead to lug 1 (S-3).

N SW W2 L7 INNER
L5 SHIELD

B (X) Cable H78 to control R6/R7: inner lead to lug 2 (S-2), and shield lead to lug 6 (S-2). Carefully position the cable so the shield lead does not touch lug 5.

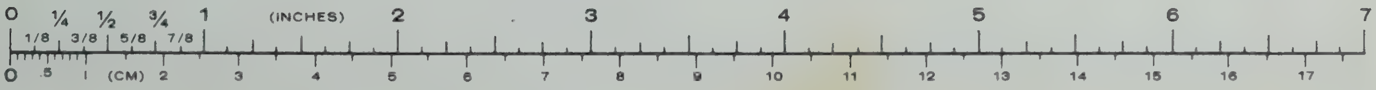


Detail 11-7B

B OK ( ) Carefully examine binding posts CC and CD, terminal strip B10, and control R6/R7 for proper lead connection. The bare leads must not touch adjacent lugs, leads, or the chassis.

( ) Position the level switch/5000 Ω control (SW6/R32) as shown in Detail 11-7B. Loosen and remove the indicated nut and lockwasher. Then install a #6 solder terminal, reinstall the lockwasher and nut, and tighten the hardware. Position the solder terminal so it is pointed in the same direction and parallel to the control lugs.

( ) Bend all of the lugs on switch SW6/R32 wafer 1 over approximately 90°toward the control.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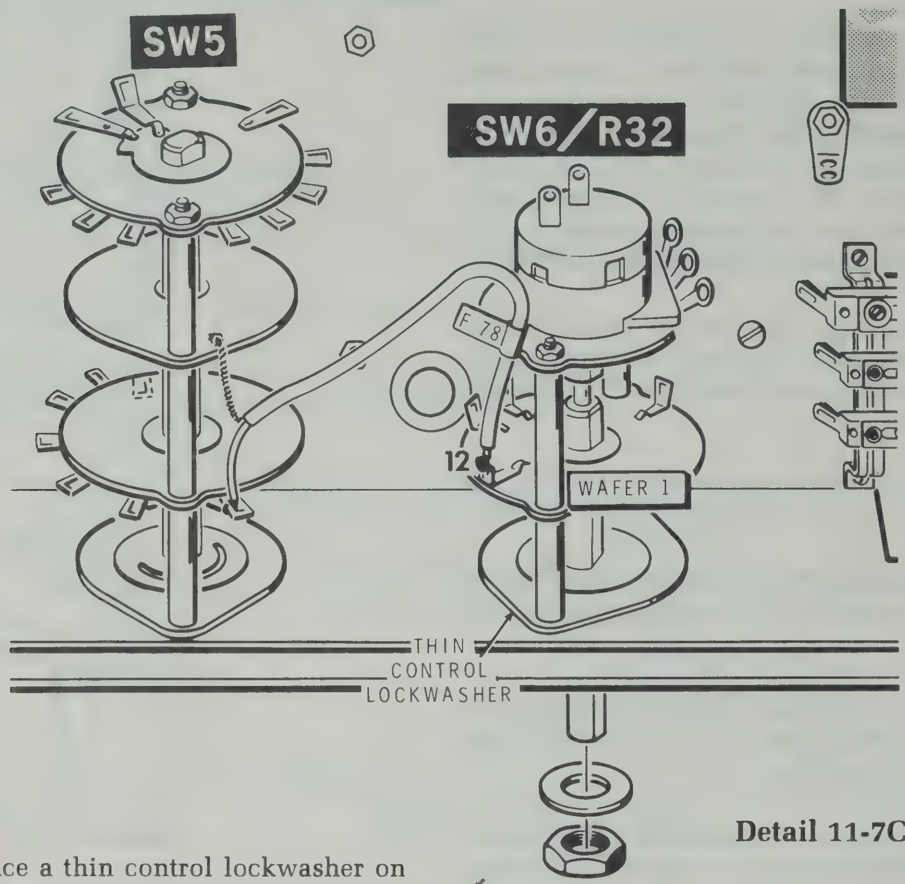
1/8 3/8 5/8 7/8
0 .5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



Detail 11-7C

B
OK

(X) SW6/R32: Place a thin control lockwasher on the shaft of the level switch/5000 Ω control. Then mount the switch/control to the front panel at SW6/R32 with a control flat washer and a control nut. Position the switch/control as shown in Detail 11-7C.

-N SW5 W1 L7 - INNER
PLATE - SHLD

B (✓) Connect the inner lead of coaxial cable F78 coming from switch SW5 to switch/control SW6/R32 wafer 1 lug 12 (NS). Cut off the shield lead.

B (✓) Loosen the control nut on switch/control SW6/R32 and turn the switch/control counterclockwise so that cable F78 is pulled under the switch. Position the switch/control as shown in the Pictorial and tighten the control nut. Note that the switch is rotated beyond vertical about 30°. This is to provide clearance for the cam nut you will install in a later step.

B B SW5 W1 L3 - INNER
PLATE . SHLD

(✓) Route coaxial cable D78 from switch SW5, under switch SW5. Then connect the inner lead to switch/control SW6/R32 wafer 1 lug 5 (S-1). Connect the shield lead to the solder terminal (NS).

OK
(✓) R33: Connect a 330 Ω (orange-orange-brown) resistor from switch/control SW6/R32 control lug 1 (S-1) to the solder terminal (NS). Keep the resistor body down near the control.

OK
(✓) Prepare a 3-3/4" black wire and connect either end to the solder terminal (S-3) on switch/control SW6/R32. Connect the other end to solder lug B9 (NS).

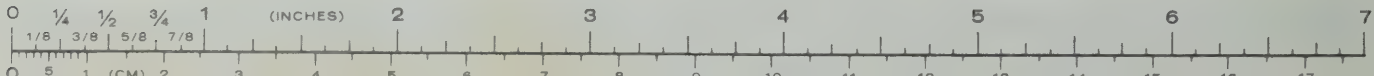
B (✓) Connect the white wire from switch SW5 to switch/control SW6/R32 control lug 3 (S-1).

B (✓) Connect the red wire from switch SW5 to switch/control SW6/R32 control lug 2 (S-1).

OK
(✓) Connect the white wire coming from trimmer C4 to switch/control SW5/R32 wafer 1 lug 12 (S-2).

OK
(✓) Connect the red wire coming from trimmer C4 to switch/control SW6/R32 wafer 1 lug 11 (S-1).

OK
(✓) Connect the white wire coming from trimmer C6 to switch/control SW6/R32 wafer 1 lug 10 (S-1).


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

ok (X) Connect the black wire coming from trimmer C6 to solder lug B9 (NS).

ok (X) Connect the bare wire coming from the meter amplifier circuit board to solder lug B9 (S-3).

Connect the wires from the auto null wire harness to switch SW2 as follows:

ok (X) White-gray wire to lug 6 (S-1).

ok (X) White-black wire to lug 5 (S-1).

ok (X) White-violet wire to lug 4 (S-1).

ok (X) White-green wire to lug 3 (S-1).

ok (X) White-yellow wire to lug 2 (S-1).

ok (X) White-orange wire to lug 1 (S-1).

ok ( ) Prepare a 3-3/4" red wire and connect either end to red binding post CA (S-1). Connect the other end to the meter amplifier circuit board, hole F (S-1).

ok (X) Prepare a 3-3/4" black wire and connect either end to black binding post CB (S-1). Connect the other end to the meter amplifier circuit board, hole D (S-1).

ok (X) Connect the bare wire coming from the power supply circuit board to solder lug B13 (S-1).

ok ( ) Unfold the power supply wire harness, position the wire harness on the chassis as shown.

Route the indicated harness wires through the chassis grommets as follows:

ok (X) White-blue and white-orange from breakout 2 through grommet B4.

ok (X) All wires from breakout 1, except the large brown twisted pair, through grommet B2.

(X) Red and violet wires from breakout 4 through grommet B1.

Connect the harness wires as follows:

NOTE: Make a mechanically secure connection with a wire when you are instructed to do so, as in the following step. Wrap the wire around the lug before you solder the wire, as shown in the inset drawing.

(X) Either large brown wire from breakout 3 to switch/control SW6/R32 power switch lug 1 (S-1). Make a mechanically secure connection.

(X) Remaining large brown wire from breakout 3 to switch/control SW6/ R32 power switch lug 2 (S-1). Make a mechanically secure connection.

(X) Orange wire from breakout 4 to bridge amplifier circuit board hole R (S-1).

(X) Blue wire from breakout 4 to bridge amplifier circuit board hole J (S-1).

(X) Either large brown wire from breakout 1 to fuse block A2 lug 2 (S-1). Make a mechanically secure connection.

(X) Other large brown wire from breakout 1 to switch SW1 lug 6 (NS). Make a mechanically secure connection.

Connect the four power transformer primary wires from grommet B3 to switch SW1 as follows. Make a mechanically secure connection with each wire.

(X) Black-red wire to lug 6 (S-2).

(X) Black-yellow wire to lug 5 (S-1).

(X) Black wire to lug 1 (NS).

(X) Black-green wire to lug 2 (S-1).

Position the wires against the rear panel.

B (X) Connect the inner lead of coaxial cable L12 from switch SW5 to the auto null circuit board, hole C (S-1). Cut off the shield lead.

ok (X) Connect the bare wire from the auto null circuit board to solder lug B14 (S-1).

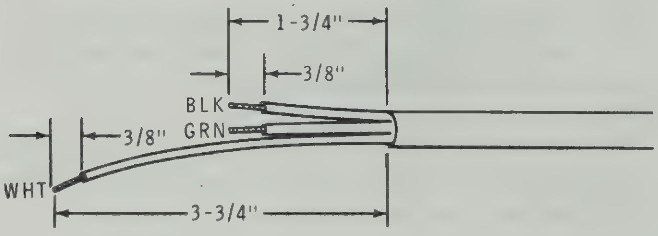
NOTE: Form the resistor leads before you install the following resistor. Then cut off each lead so there is no excess lead length. You will not be able to cut off the excess leads after it is connected to the circuit board.

B (X) R127: Connect a 100 Ω (brown-black-brown) resistor from the bridge amplifier circuit board hole U (S-1) to switch SW5 wafer 2 lug 2 (S-1). Position the resistor **1/8" above** and **parallel** to the chassis.

NOTE: This instrument can be operated from a 120 VAC or a 240 VAC power source.

(X) Use a screwdriver to set switch SW1 to the position that will match your line voltage. For 120 VAC operation, slide the switch wiper so "120" is visible. For 240 VAC operation, slide the switch wiper so "240" is visible. The switch wiper is accessible through a hole in the rear panel.

CAUTION: Electrical regulations in some areas require a special line cord and/or plug for 240-volt operation. If the line cord and plug supplied with this instrument are not approved for your area, obtain an approved cord and plug locally, and proceed with the following steps, making changes as necessary.



Detail 11-7D

ok (X) Refer to Detail 11-7D and prepare the line cord wires. NOTE: Be sure to melt a small amount of solder on the wire ends after they are prepared.

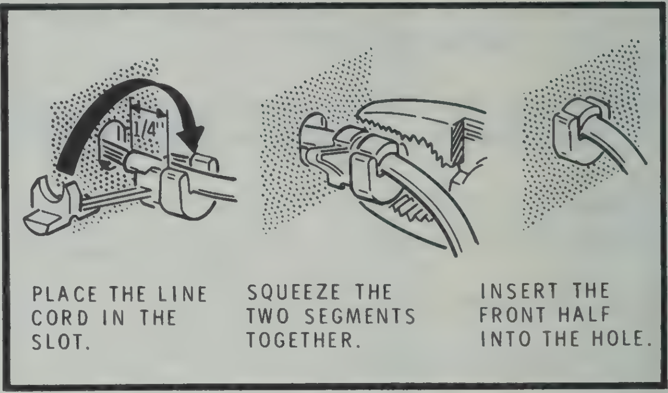
ok (–) Pass the prepared line cord wires through rear panel hole A1.

Connect the line cord wires in the following steps. Make a mechanically secure connection with each wire before you solder the wire.

(X) Green wire to solder lug B6 (S-1).

(X) Black wire to fuse block A2 lug 1 (S-1).

(X) White wire to switch SW1 lug 1 (S-2).


1/4"
PLACE THE LINE CORD IN THE SLOT.
SQUEEZE THE TWO SEGMENTS TOGETHER.
INSERT THE FRONT HALF INTO THE HOLE.

Detail 11-7E

(✓) Secure the line cord to the rear panel with the line cord strain relief as shown in Detail 11-7E.

(✓) F1: Install a 1/2-ampere slow-blow fuse into fuse block A2. NOTE: The fuse value is identical for both 120 and 240-volt operation.

(✓) Remove the backing paper from the fuse label and stick the label to the chassis near switch SW1 and the power wire harness as shown. Write the fuse value and type (1/2-ampere, slow-blow, 3AG) on the fuse label.

(✓) Carefully examine the chassis bottom to make sure all of the wires and leads are properly soldered and there are no solder splashes or wire ends that could cause a circuit short.

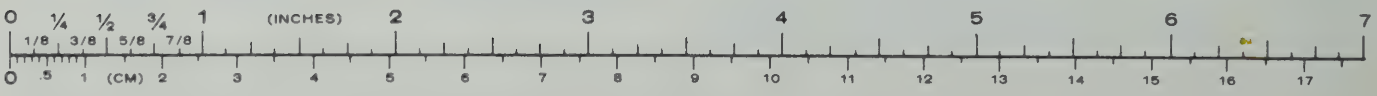
Refer to Pictorial 11-8 for the following steps.

(X) Position the chassis as shown.

Connect the wires from grommet B1 to the auto null amplifier circuit board as follows:

ok (X) Violet wire to hole G (S-1).

ok (X) Red wire to hole F (S-1).


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 .5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Connect the wires from grommet B2 to the power supply circuit board as follows:

ok (X) White-blue wire to hole M (S-1).

ok (X) Blue wire to hole L (S-1).

ok (X) Violet wire to hole K (S-1).

ok (X) Red wire to hole J (S-1).

ok (X) Orange wire to hole H (S-1).

ok (X) White-orange wire to hole G (S-1).

Connect the three power transformer wires to the power supply circuit board as follows:

ok (X) Red-yellow wire to hole C (S-1).

ok (X) Either red wire to hole B (S-1).

ok (X) Other red wire to hole A (S-1).

Connect the wires from grommet B4 to the meter amplifier circuit board as follows:

ok (X) White-orange wire to hole E (S-1).

ok (X) White-blue wire to hole H (S-1). Route the wire as shown.

ok (X) Connect the inner lead of the coaxial cable from the auto null wire harness to meter amplifer circuit board hole G (S-1). Connect the shield lead to hole J (S-1).

ok (X) Twist the remaining red, white, and black wires together for a length of 12″ and cut off the excess wire lengths. Then remove 1/4″ of insulation from both ends of each wire.

Connect the 3-wire cable to the power supply circuit board as follows:

ok (X) Red wire to hole D (S-1).

ok (X) White wire to hole E (S-1).

ok (X) Black wire to hole F (S-1).

ok (X) Route the 3-wire cable near the chassis as shown, and up to the lamp sockets.

ok (X) Remove an extra 1/4″ of insulation from the black wire. Then pass the wire through socket PL1 lug 2 (S-2) and connect it to socket PL2 lug 2 (S-1).

ok (X) Connect the red wire to socket PL2 lug 1 (S-1).

ok (X) Connect the white wire to socket PL1 lug 1 (S-1).

(X) Twist the remaining red and white wires together for a length of 8″ and cut off the excess wire lengths. Then remove 1/4″ of insulation from both ends of each wire.

Connect one end of the 2-wire cable to the meter amplifier circuit board as follows:

ok (X) Red wire to hole B (S-1).

ok (X) White wire to hole C (S-1).

(X) Route the 2-wire cable near the chassis as shown.

ok (X) Connect the red wire to the positive (+) meter lug (S-1).

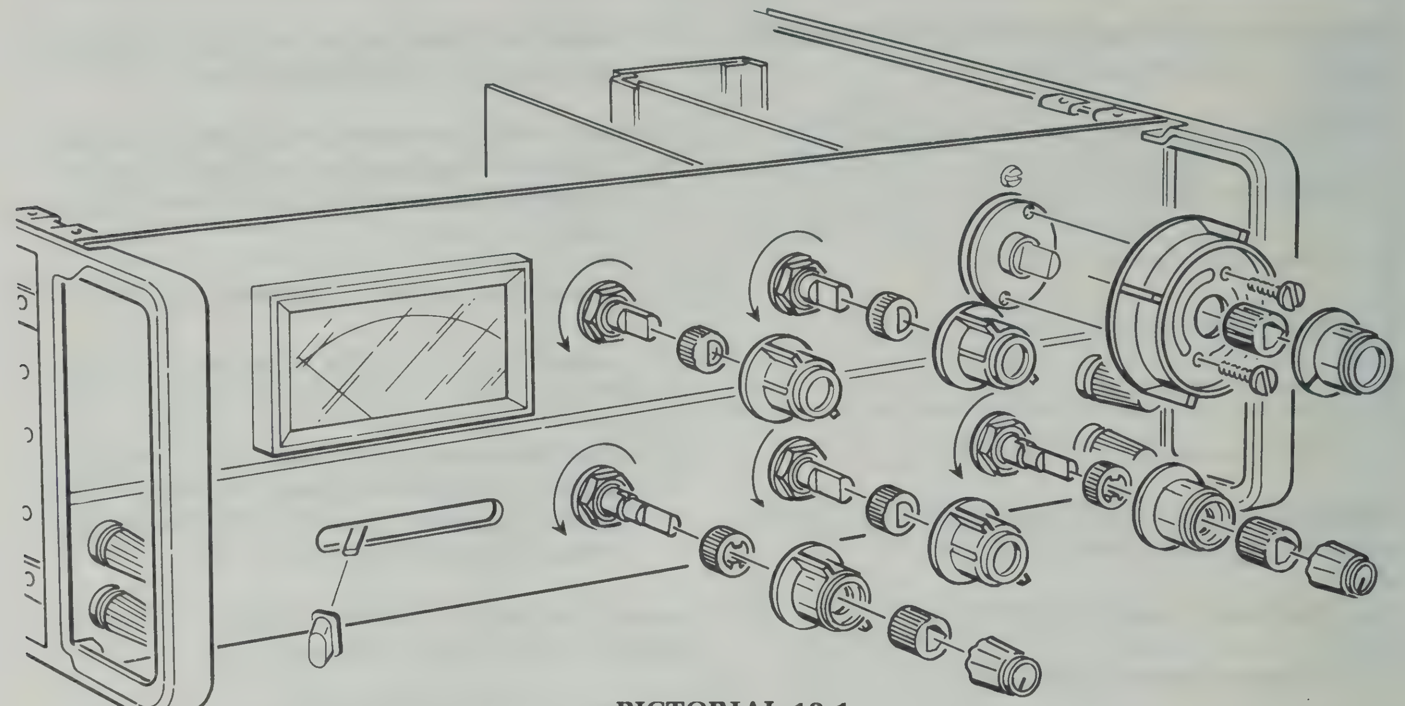
ok (X) Connect the white wire to the negative (−) meter lug (S-1).

ok (X) Rotate the variable capacitor coupling back and forth a couple of times to center the reduction drive in its mounting.

ok (X) Tighten the reduction drive mounting hardware.

(X) Tighten the two reduction drive set screws.

(X) Carefully examine the chassis to make sure all of the wires and leads are properly soldered and there are no solder splashes or wire ends that could cause a circuit short. NOTE: The five loose wires on the frequency range switch will be connected in a later step.



PICTORIAL 12-1

KNOB INSTALLATION

Refer to Pictorial 12-1 for the following steps.

(✓) Press a short D-hole knob bushing onto the Meter Range switch shaft, large end first.

(✓) Rotate the switch shaft fully counterclockwise. Then turn the shaft clockwise five "clicks."

(✓) Lightly press a black knob with wings (#462-999) onto the bushing so the wing with white pointer is positioned in line with the SET LEVEL mark on the front panel.

(✓) Carefully pull the knob and knob bushing off together.

(✓) Refer to Detail 12-1A and drive the knob bushing into the knob with a nut driver or similiar object, so the top of the bushing is even with the inside ledge of the knob.

( ) Reinstall the knob on the Meter Range switch.

( ) Press a second short D-hole knob bushing onto the Frequency Range switch shaft, large end first.

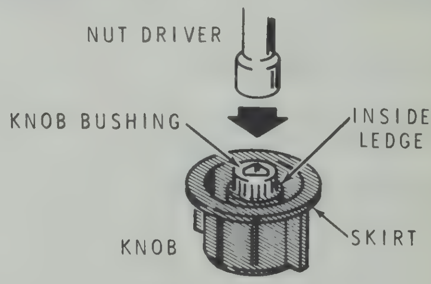
( ) Rotate the switch shaft fully counterclockwise. Then turn the shaft clockwise two "clicks."

( ) Press a black knob with wings (#462-999) onto the bushing so the pointer is in line with the 100 - lk mark. Then remove the knob and bushing, drive the bushing into the knob, and reinstall the knob.

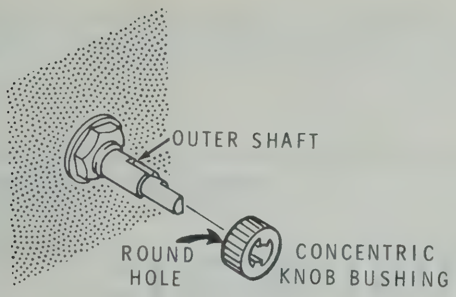
( ) Press a third short D-hole knob bushing onto the Function switch shaft, large end first.

( ) Rotate the switch shaft fully counterclockwise. Then turn the shaft clockwise one "click."

( ) Press a black knob with wings (#462-999) onto the bushing so the pointer is in line with the SET LEVEL mark. Then remove the knob and bushing, drive the bushing into the knob, and reinstall the knob.



Detail 12-1A



Detail 12-1B

(✓) Refer to Detail 12-1B and press a short concentric knob bushing onto the outer shaft of the Level switch. Note that the end of the bushing that is completely round is positioned toward the front panel.

(✓) Rotate the switch fully counterclockwise. Then turn the shaft clockwise one "click."

(✓) Press a black concentric knob with wings (#462-951) onto the bushing so the pointer is in line with the MID mark. Then remove the knob and bushing, drive the bushing into the knob, and reinstall the knob.

( ) Press a tall small-hole knob bushing onto the small Level control shaft, large end first.

(✓) Rotate the control fully counterclockwise into its detent ("click") position.

(✓) Align the pointer of a red knob with the POWER OFF mark on the front panel and press the knob onto the bushing. Then remove the knob and bushing, drive the bushing into the knob, and reinstall the knob.

( ) Press a short concentric knob bushing onto the outer Balance control shaft, large end first.

( ) Turn the control to the center of its rotation.

( ) Press a black concentric knob without wings (#462-361) onto the bushing so the pointer is pointing straight up.

(✓) Rotate the control fully clockwise and counterclockwise. If necessary, reposition the knob on the bushing so the knob pointer is the same distance from the bottom of the front panel at each end of its rotation.

( ) Remove the knob and bushing, drive the bushing into the knob, and reinstall the knob.

( ) Press a tall small-hole knob bushing onto the small Balance control shaft, large end first.

( ) Rotate both balance control shafts fully counterclockwise.

( ) Align the pointer of a red knob with the pointer on the black knob and press the red knob onto the bushing. Then remove the knob and bushing, drive the bushing into the knob, and reinstall the knob.

( ) Press the lever knob onto the Mode switch shaft, as far as it will go. Note the correct positioning of the knob.

( ) Remove the two knob mounting screws from the variable capacitor reduction drive. Then mount the tuning knob to the drive with the two screws you just removed. Disregard the position of the knob pointer.

( ) Loosen the two setscrews on the reduction drive (so the knob will turn without turning the variable capacitor).

( ) Make sure the variable capacitor is turned fully counterclockwise. Then turn the tuning knob so the pointer is pointing directly at the Frequency Range switch. Tighten the two setscrews. If the screws are not accessible, remove the tuning knob, turn it 180 degrees, and reinstall the knob. Turn the knob as previously directed.

( ) Press the tall large-hole knob bushing onto the Frequency Tuning control shaft, large end first.

( ) Align the pointer of a black knob without wings (#462-1022) with the pointer on the tuning knob and press the black knob onto the bushing. Then remove the knob and bushing, drive the bushing into the knob, and reinstall the knob. NOTE: Drive the bushing into the knob so its end is even with the skirt of the knob.

This completes the "Step-by-Step Assembly." Proceed to "Initial Tests and Adjustments."

INITIAL TESTS AND ADJUSTMENTS

In the following steps, you will perform a number of tests and adjustments. This will require a DC voltmeter with a minimum of 1 MΩ input impedance, an ohmmeter, and a sine-wave generator with 1000 Hz and 100 kHz outputs. If the generator does not have a calibrated output, an AC voltmeter will be required. An oscilloscope is useful, but not necessary.

We recommend that you refer to the "Operation" section on Page 70 and familiarize yourself with the Harmonic Distortion Analyzer before you begin the tests.

NOTE: If at any time you do not obtain the results indicated, refer to the "In Case of Difficulty" section on Page 74.

( ) Refer to Figures 1, 2, and 3 and preset the circuit board controls, and the front panel controls and switches as follows:

Meter Amplifier Circuit Board:
BIAS ADJ control R202 — Fully counterclockwise.
CALIBRATE control R205 — Fully counterclockwise.

Null Amplifier Circuit Board:
BIAS control R125 — Center of rotation.

Bridge Amplifier Circuit Board:
BIAS ADJ control R108 — Center of Rotation.

Front Panel:
MODE switch — MANUAL.
METER RANGE switch — SET LEVEL (.3 VOLTS).
LEVEL switch — MAX.
LEVEL control — POWER OFF.
FREQUENCY RANGE switch — 10 k–100 k.
FUNCTION switch — VOLTMETER.
FREQUENCY TUNING control — 100.
BALANCE COARSE control — Center of rotation.
BALANCE FINE control — Center of rotation.
METER ZERO screw — Center meter pointer over "0" mark. NOTE: Tap the meter face as you make this adjustment.

PRIMARY WIRING TESTS

A wiring error in the primary wiring circuit (line cord, power switch, etc.) of your kit could cause you to receive a severe electrical shock. These "Primary Wiring Tests" will assure you that no such wiring errors exist.

Make sure there are no fine strands or wire of solder blobs touching adjacent terminals or the chassis. Then use an ohmmeter to perform the following resistance measurements. NOTE: You will be instructed to connect one of the ohmmeter leads to ground. This ground should be at one of the circuit board ground wires.

( ) Place the ohmmeter range switch in the "X10" position. Then perform the following checks.

METER CONNECTIONS			
RED LEAD	BLACK LEAD	METER READING	POSSIBLE CAUSE OF TROUBLE
1. Either flat prong of the line cord plug. ✓	Ground.	INFINITE with the POWER switch ON or OFF.	A. POWER switch wiring. B. Transformer. C. Line cord. D. 120/240 switch wiring.
2. Other flat prong of the line cord plug. ✓	Ground.	INFINITE with the POWER switch ON or OFF.	A. POWER switch wiring. B. Transformer. C. Line cord D. 120/240 switch wiring.
3. Round prong of the line cord plug. ✓	Ground.	0 Ω with the POWER switch ON or OFF.	A. Green lead of line cord nor properly connected at the solder lug.
4. Either flat prong of the line cord plug. ✓	Other flat prong of the line cord plug.	1 MΩ or higher with the POWER switch OFF.	A. Transformer. B. POWER switch wiring. C. Line cord. D. 120/240 switch wiring.
5. Either flat prong of the line cord plug. ✓	Other flat prong of the line cord plug.	15 Ω ±20% (×1 range) with the POWER switch ON, and 120/240 switch in 120 position.	A. Transformer. B. POWER switch wiring. C. Line cord. D. 120/240 switch wiring. E. Fuse.

(✓) Turn the POWER switch OFF.

ADJUSTMENTS

WARNING: When the line cord is connected, dangerous AC voltage is present on the rear panel and switch SW6/R32. Refer to Figure 2.

(✓) Plug the line cord plug into an AC receptacle.

NOTE: For all of the DC voltage measurements, connect the common voltmeter lead to the black INPUT binding post.

(✓) Connect the DC voltmeter input to the positive (+) lead of capacitor C401, on the power supply circuit board. See Figure 1.

(✓) Turn the Analyzer on and rotate the LEVEL control fully clockwise. The Analyzer meter should light and the pointer should indicate less than 1 on the 0 - 3 meter scale. The DC voltmeter should indicate +24 volts, ± 1.5 volts. NOTE: Because of the sensitivity of the meter circuits, the meter pointer will fluctuate a great amount at turn-on, turn-off, and during some of the following adjustments.

(✓) Connect the DC voltmeter input to the negative lead of capacitor C404, on the power supply circuit board. The meter should read −24 volts, ±1.5 volts.

Allow the Analyzer 20 minutes to warmup before you proceed.

(✓) Connect the DC voltmeter input to the collector of transistor Q203 on the meter amplifier circuit board. Then adjust BIAS ADJ control R202 for 7 volts.

(✓) Connect the DC voltmeter input to the collector of transistor Q103 on the bridge amplifier circuit board. Adjust BIAS ADJ control R108 for +3.5 volts.

(✓) Connect the DC voltmeter input to the collector of transistor Q108 on the null amplifier circuit board. Adjust BIAS control R125 for −15.5 volts.

NOTE: Because of the sensitivity of the meter amplifier circuit, the meter will always display a small residual voltage. This will not affect the accuracy of any reading above the residual level.

(✓) Set the output of your sine-wave generator for 1000 Hz at 0.3 volts rms, and connect it to the INPUT binding posts of the Analyzer.

CANT GET IT UP TO 3

( ) Adjust the meter pointer, with CALIBRATE control R205 on the meter amplifier circuit board so it is directly over the "3" on the 0 - 3 meter scale.

( ) Turn the METER RANGE switch to 1 VOLT. Note the meter indication on the 0 - 10 scale.

( ) Turn the METER RANGE switch to .3 VOLTS.

( ) Set the output of your generator for 100 kHz. If necessary, readjust the generator output so the Analyzer meter still indicates "3" on the 0 - 3 scale.

( ) Turn the METER RANGE switch to 1 volt.

( ) With a nonconductive alignment tool, adjust trimmer C2, on the METER RANGE switch (SW4), for a meter reading identical to the reading you noted previously.

( ) Turn the METER RANGE switch to SET LEVEL.

( ) Turn the FUNCTION switch to SET LEVEL.

( ) Position the Analyzer bottom side up.

( ) Adjust the output level of your generator so the Analyzer meter indicates "10" on the 0 - 10 scale.

( ) Turn the LEVEL switch to MID.

( ) Adjust trimmer C4 for a meter reading of "1" on the **0-10 scale**.

( ) Adjust the output level of your generator so the Analyzer meter indicates "10" on the 0 - 10 scale.

( ) Turn the LEVEL switch to MIN.

( ) Adjust trimmer C6 for a meter reading of "1" on the 0 - 10 scale.

( ) Turn the LEVEL switch to MAX.

( ) Repeat the previous seven steps until there is no further need for adjustment.

( ) Adjust the output level of your generator so the Analyzer meter indicates "10" on the 0 - 10 scale.

( ) Reposition the Analyzer bottom side down.

NOTE: If you have an oscilloscope, connect the Analyzer output to the vertical input, and the generator output to the external horizontal input (x-y operation). This will allow you to observe the frequency nulling process.

( ) Turn the FUNCTION switch to DISTORTION.

NOTE: In the following steps you will adjust the bridge circuit for a null condition (as indicated by the meter).

( ) With the generator still adjusted for 100 kHz, adjust the FREQUENCY TUNING control on the Analyzer for null (minimum meter deflection).

( ) Adjust trimmer C120, on the bridge amplifier circuit board, for null.

( ) Repeat the two previous steps until there is no further reduction in the meter display. It will be necessary to increase the sensitivity of the meter (turn the METER RANGE switch counterclockwise) as you reach null. NOTE: As your adjustments become more critical, stray capacitance from your hand and the trimmer adjusting tool will affect the trimmer adjustment. Therefore when you adjust the trimmer, turn the screw a small amount, remove the tool, and observe the new meter indication.

( ) Adjust the COARSE and FINE BALANCE controls for null.

( ) Readjust the FREQUENCY TUNING control and trimmer C120 for null.

( ) Repeat the two previous steps until there is no further reduction in the meter display. NOTE: The total harmonic distortion of the generator and the Analyzer will determine the final meter indication.

( ) Turn the METER RANGE switch to SET LEVEL.

( ) Turn the FUNCTION switch to SET LEVEL.

( ) Turn the Analyzer off.

( ) Unsolder and remove the violet wire from hole FF on the null amplifier circuit board.

( ) Unsolder and remove the white wire from hole AA on the null amplifier circuit board.

( ) Turn the Analyzer on.

In the following steps, you will measure and adjust the resistance of the five photo resistors on the optical isolator circuit board. Figure 4 shows the lead location for each resistor. To perform the adjustment operation:

1. Measure the resistance of a photo resistor.
2. If the resistance is incorrect, remove the resistor housing top and reposition the resistor body (nearer the lamp to decrease the resistance; away from the lamp to increase the resistance). NOTE: You can move the photo resistor vertically or horizontally to make this adjustment.
3. Reinstall the housing top and measure the resistance again. NOTE: You may have to reposition the resistor several times before you obtain the correct resistance. Always install the housing top before you measure the resistance.

Adjust the resistance of the following five photo resistors within the specified values.

( ) Photo resistor R501 — 140 kΩ to 160 kΩ.

( ) Photo resistor R502 — 14 kΩ to 20 kΩ.

( ) Photo resistor R503 — 140 kΩ to 160 kΩ.

( ) Photo resistor R504 — 14 kΩ to 20 kΩ.

( ) Photo resistor R505 — 28 kΩ to 32 kΩ.

( ) Turn the Analyzer off.

Connect the two wires you previously disconnected to the null amplifier circuit board as follows:

( ) White wire to hole AA (S-1).

( ) Violet wire to hole FF (S-1).

Connect the five wires from switch SW3 to the optical isolator circuit board as follows:

( ) Yellow wire to hole A (S-1).

( ) Red wire to hole B (S-1).

( ) White-gray wire to hole C (S-1).

( ) Green wire to hole D (S-1).

( ) White-brown wire to hole E (S-1).

( ) Carefully cut off the loose wire ends. Do not let the wire pieces fall into the chassis.

( ) Turn the Analyzer on and rotate the LEVEL control fully clockwise. The meter should still read "10" on the 0 - 10 scale.

( ) Turn the FUNCTION switch to DISTORTION.

( ) Turn the METER RANGE switch to a range that gives a useful meter indication. Note the meter reading.

( ) Move the MODE switch to AUTO. After the meter settles down, it should indicate a value approximately equal to the value in the previous step. NOTE: At this sensitivity level it is very difficult but possible, to manually adjust this instrument more accurately than with the auto null circuits, by a very small percentage.

( ) Move the MODE switch to MANUAL.

( ) Turn the METER RANGE switch to SET LEVEL.

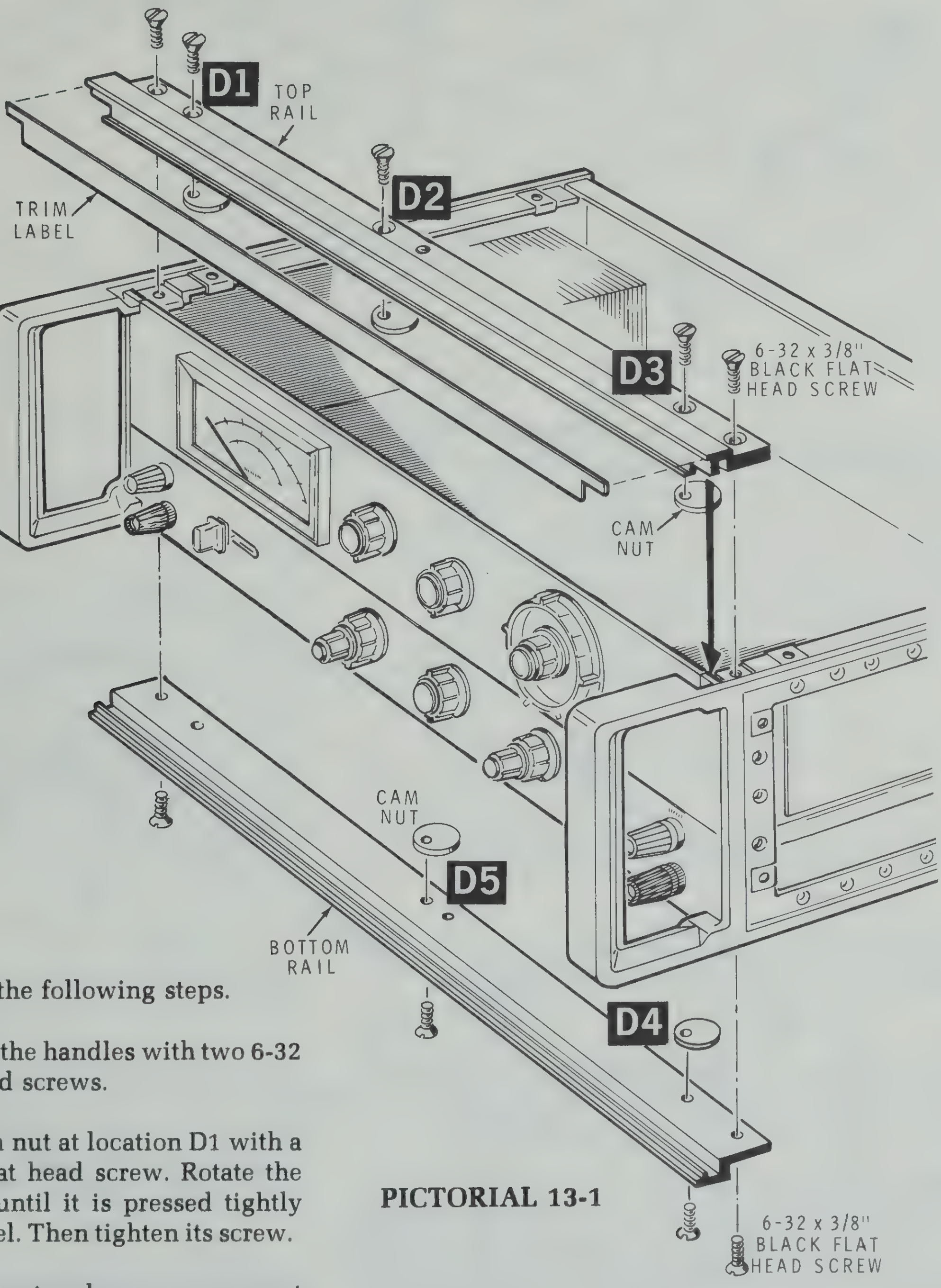
( ) Turn the FUNCTION switch to SET LEVEL.

( ) Disconnect the generator and oscilloscope.

( ) Turn the Analyzer off and disconnect the line cord plug.

This completes "Test and Adjustments." Your instrument is fully calibrated. After about 48 hours use, you should recalibrate the Analyzer to compensate for any initial "ageing" component drift. Refer to the "Calibration" section for any future calibration. Proceed to "Final Assembly."

FINAL ASSEMBLY


D1
TOP RAIL
TRIM LABEL
D2
D3
6-32 x 3/8" BLACK FLAT HEAD SCREW
CAM NUT
CAM NUT
D5
BOTTOM RAIL
D4
6-32 x 3/8" BLACK FLAT HEAD SCREW

PICTORIAL 13-1

Refer to Pictorial 13-1 for the following steps.

( ) Mount the top rail to the handles with two 6-32 × 3/8" black flat head screws.

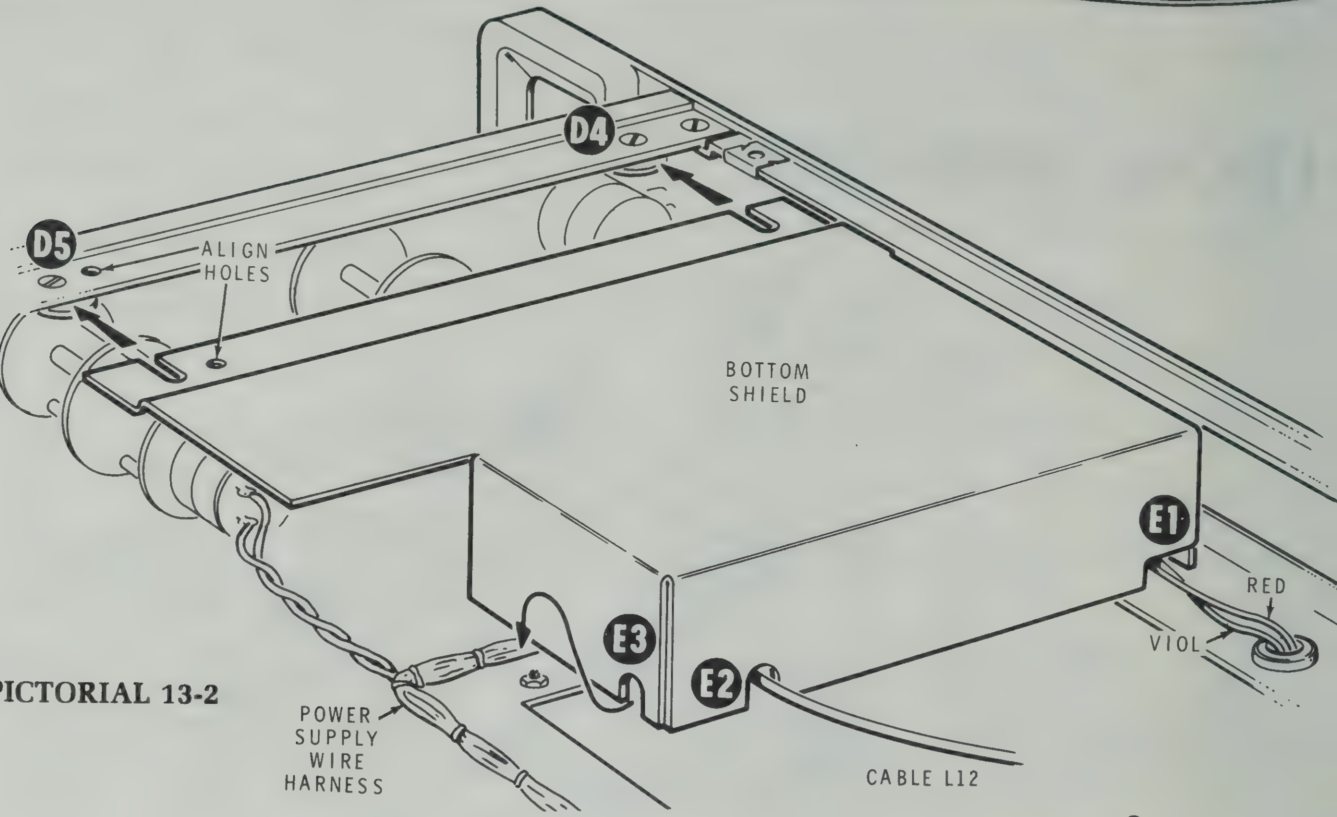
( ) Loosely mount a cam nut at location D1 with a 6-32 × 3/8" black flat head screw. Rotate the cam nut clockwise until it is pressed tightly against the front panel. Then tighten its screw.

( ) In a like manner, mount and secure a cam nut with a 6-32 × 3/8" black flat head screw at locations D2 and D3.

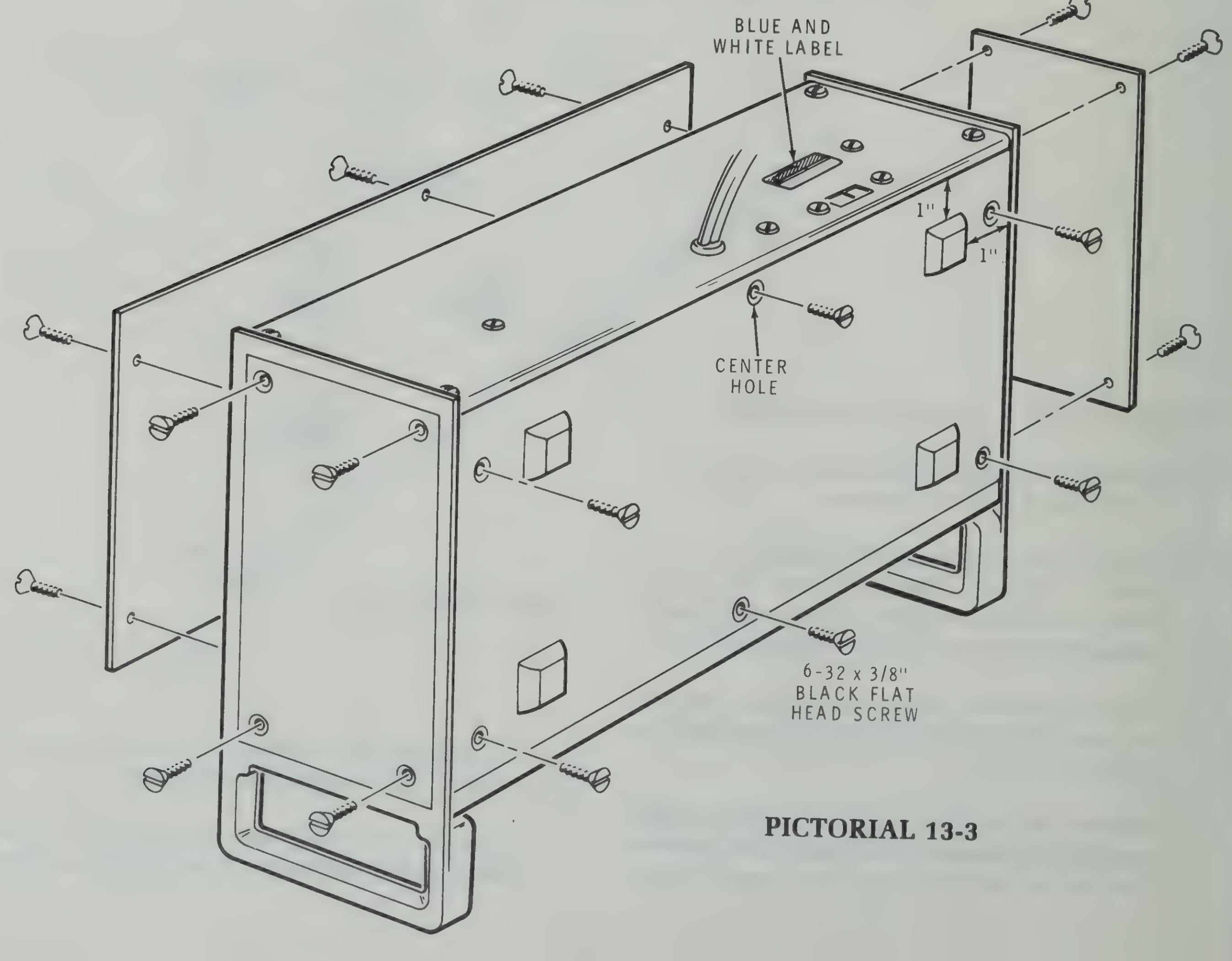
( ) Remove the backing paper from the trim label, carefully position the label inside the groove in the top rail, and press the label onto the rail.

( ) Mount the bottom rail to the handles with two 6-32 × 3/8" black flat head screws.

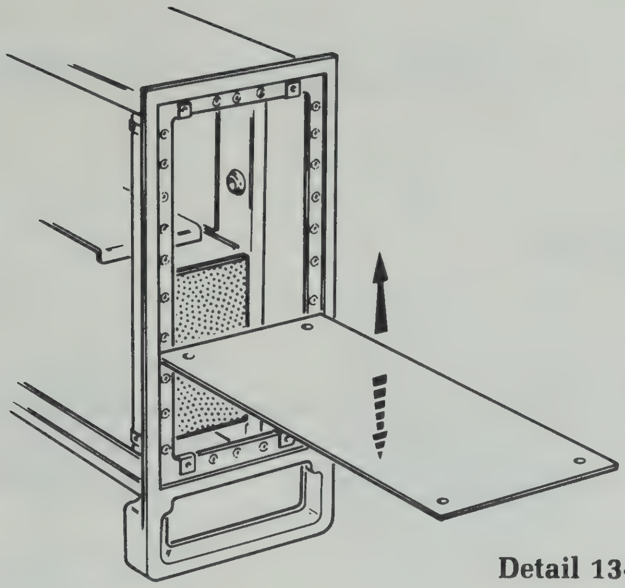
( ) Loosely mount a cam nut with a 6-32 × 3/8" black flat head screw at locations D4 and D5.
]



PICTORIAL 13-2



PICTORIAL 13-3



Detail 13-3A

( ) Refer to Pictorial 13-2 and slide the bottom shield between the bottom rail and the cam nuts at D4 and D5. Make sure the coaxial cable and blue wire on the bridge amplifier circuit board are inside the shield, the red and violet wires pass through cutout E1, coaxial cable L12 passes through cutout E2, and the power supply wire harness passes through cutout E3. Then tighten the screws at D4 and D5. NOTE: Make sure the threaded hole in the bottom rail is aligned with the hole in the bottom shield.

Refer to Pictorial 13-3 for the following steps.

NOTE: It may be necessary to align some of the push-on nuts before you can start the screws into them.

( ) Mount the top/bottom panel to the bottom of the Analyzer with six 6-32 × 3/8″ black flat head screws. Note that the two center holes on the panel are not an equal distance from the edge of the panel. Position the panel for proper hole alignment.

( ) Remove the backing paper from a plastic foot and press the foot onto the bottom panel in a corner, 1″ from each edge of the panel.

( ) In a like manner, mount three more plastic feet to the bottom panel as shown.

( ) Refer to Detail 13-3A and slide the edge of a side panel into the recessed area of the handle that supports the null amplifier circuit board. Shift the panel back and forth to make sure none of the component leads extend too far and make contact with the panel. Then examine the top edge of the circuit board to make sure the handle does not make contact with any of the soldered foil connections.

( ) Mount the side panel to the handle with four 6-32 × 3/8″ black flat head screws.

( ) Mount the remaining side panel to the other handle with four 6-32 × 3/8″ black flat head screws.

( ) Mount a top/bottom panel to the top of the Analyzer with six 6-32 × 3/8″ black flat head screws.

( ) Remove the backing paper from the blue and white identification label and press the label onto the rear panel near the line cord as shown.

NOTE: The blue and white label shows the Model number and Production Series number of your kit. Refer to these numbers in any communications with the Heath Company; this assures you that you will receive the most complete and up-to-date information in return.

This completes the "Final Assembly." Proceed to the "Operation" section.

OPERATION

This section of the Manual explains the function of each control, switch, and connector; describes several operational examples; and provides general operating information.

CONTROLS-SWITCHES-CONNECTORS

Refer to Figure 3 for the following descriptions.

1. Meter — indicates distortion or voltage level of input. Illuminates when the analyzer is turned on. Access to the meter zero screw provided for mechanical setting of the meter zero.
2. METER RANGE switch — selects the full scale range of the meter in percent, rms volts, or dB. This is dependent on the Function switch setting.
3. FREQUENCY RANGE switch — selects the frequency range which corresponds to the fundamental frequency of the input signal.
4. FREQUENCY TUNING control (coarse)— tunes the Wien bridge circuit to the fundamental frequency of the input signal.
5. FREQUENCY TUNING control (fine) — provides fine adjustment of the coarse control.
6. INPUT binding posts — provide connection for the input signal. The black binding post is connected to circuit (and chassis) ground.
7. COARSE BALANCE control — provides a coarse adjustment for balancing the Wien bridge circuit.
8. FINE BALANCE control — provides a fine adjustment for balancing the Wien bridge circuit.
9. FUNCTION switch — selects the type of operation of the Analyzer.
10. LEVEL switch — provides two decades of input signal attenuation in the SET LEVEL and DISTORTION functions. The MAX position does not attenuate the signal.
11. LEVEL control — provides a continuous attenuation adjustment between LEVEL switch positions. The Analyzer POWER OFF switch is ganged with the LEVEL control, and is used to turn the Analyzer AC power on.
12. MODE switch — selects MANUAL or AUTO bridge tuning operation.
13. OUTPUT binding posts — provides a means of monitoring the output of the meter circuit.

OPERATIONAL EXAMPLES

DISTORTION MEASUREMENT

Before you begin a distortion measurement, preset the front panel controls and switches as follows:

METER RANGE switch — SET LEVEL.
FREQUENCY RANGE switch — Fundamental frequency of input signal.
FREQUENCY TUNING control — Approximate fundamental frequency of input signal.
COARSE BALANCE control — Center of rotation.
FINE BALANCE control — Center of rotation.
FUNCTION switch — SET LEVEL.
LEVEL switch — MIN (least sensitive position).
LEVEL control — Full counterclockwise to POWER OFF detent (instrument turned off).
MODE switch — MANUAL.

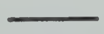
CAUTION: Always begin a measurement with the input sensitivity set for minimum. This will protect the instrument from input signals up to 300 volts rms.

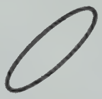
NOTE: Never turn the METER RANGE switch above SET LEVEL when the Function switch is in the SET LEVEL or DISTORTION position.

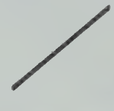
Manual Mode

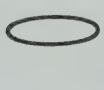
1. Turn the Analyzer on. Leave the LEVEL control in its full counterclockwise position.
2. Connect the signal to be measured to the INPUT terminals. The black binding post is connected to circuit (and chassis) ground. Minimize ground loops between instruments; refer to "General Operating Information" on Page 73.
3. Set the LEVEL switch to obtain a meter indication greater than 10% of full scale.
4. Adjust the LEVEL control for a full-scale meter indication on the 0 - 10 scale if you are making a distortion measurement in percent. Adjust the LEVEL control for 0 dB if you are making a distortion measurement in dB. NOTE: If your input signal is less than 316 mV rms, set the METER RANGE switch down-scale. Then use this new setting as the 100% or 0 dB SET LEVEL position. The other range positions will change accordingly.
5. Set the FUNCTION switch to DISTORTION.
6. Adjust the frequency tuning control, and the COARSE and FINE BALANCE controls for a minimum meter indication. Set the METER RANGE switch down-scale as necessary to keep the meter indication near the upper two-thirds of its scale (if possible).

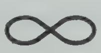
NOTE: Since the frequency and balance controls are rather sensitive in the MANUAL mode, the following information is supplied to simplify nulling. When nulling, connect the equipment as shown in Figure 5. The following waveforms with notes typify what you will see while adjusting the input signal for null.

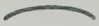
A.  No harmonic distortion. Frequency and balance adjustment correct.

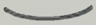
B.  Frequency and balance improperly adjusted.

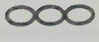
C.  Frequency approximately correct; balance incorrect.

D.  Balance approximately correct; frequency incorrect.

E.  Second harmonic predominant; frequency and balance adjusted.

F.  Second harmonic predominant; frequency and balance adjusted; phase changed.

G.  Second harmonic predominant; frequency and balance adjusted; phase changed.

H.  Third harmonic predominant; frequency and balance adjusted.

7. Repeat step 6 until no further reduction in meter indication can be obtained.

8. Observe the distortion either in percentage or dB, as indicated by the meter deflection and the METER RANGE switch setting. For example, if the meter indicates 4.0 and the METER RANGE setting is 1%, distortion measured is 0.4% of fundamental. Similarly, if the meter indication is −6 dB and the METER RANGE setting is −40 dB, distortion measured is −46 dB from fundamental.

NOTE: In the MANUAL mode, the accuracy of distortion measurement is affected by frequency stability of the input signal. An inaccuracy in distortion indications occurs when the frequency drift of the input signal exceeds the bandwidth of the rejection notch.

Automatic Mode

1. Perform steps 1 through 5 of Manual Mode operation.

2. Adjust the frequency tuning control, and COARSE and FINE BALANCE controls for minimum meter indication. When the meter indicates less than 10% of the SET LEVEL indication, set the MODE switch to AUTO. NOTE: If the fundamental signal cannot be manually nulled below 10% on the SET LEVEL range, the automatic mode cannot be used.

3. Set the METER RANGE switch down-scale as necessary to keep the meter indication near the upper two-thirds of its scale (if possible).

4. Observe the distortion either in percentage or dB, as indicated by the meter deflection and the METER RANGE switch setting, as in the "Manual Mode."

VOLTAGE MEASUREMENT

1. Before you begin a voltage measurement, preset the front panel switches as follows:

METER RANGE Switch — To a range exceeding amplitude of the signal to be measured.
FREQUENCY RANGE switch — Disregard.
FREQUENCY TUNING control — Disregard.
COARSE BALANCE control — Disregard.
FINE BALANCE control — Disregard.
FUNCTION switch — VOLTMETER.
LEVEL switch — Disregard.
LEVEL control — Fully counterclockwise to POWER OFF (Analyzer turned off).
MODE switch — Disregard.

2. Turn the Analyzer on. The LEVEL control setting is unimportant.

3. Connect the signal to be measured to the INPUT binding posts. The black binding post is connected to circuit (and chassis) ground. Avoid ground loops between instruments; refer to "General Operating Information" on Page 73.

4. Set the METER RANGE switch to give a reading as close to full scale as possible, and observe the meter indication. Refer to "General Operating Information" for a detailed explanation of the meter indication.

GENERAL OPERATING INFORMATION

INPUT CONNECTIONS

The input signal can be connected to this Analyzer through twisted wire-pair leads or a shielded cable with banana plug connectors. Keep all test leads as short as possible to avoid extraneous pickup from stray AC fields. When you measure low-level signals, it is important to minimize ground loops. One method that can be used to minimize ground loops is to connect all of the instruments to an isolation transformer.

OUTPUT BINDING POSTS

The OUTPUT binding posts provide a 0.1 volt rms open-circuit output for a full-scale meter deflection. These binding posts can be used to monitor the output signal with an oscilloscope, a true rms voltmeter, or a wave analyzer. The combination of the distortion meter and an oscilloscope provides more significant information about the device under test than the indication of distortion magnitude alone. Information obtained from the oscilloscope pattern is specific and reveals the nature of distortion, which sometimes occurs at such low levels that it is difficult to detect in the presence of hum and noise. The impedance at the OUTPUT binding posts is approximately 2000 ohms. Therefore, avoid capacitive loads greater than 50 pF to maintain the accuracy of meter readings.

VOLTMETER CHARACTERISTICS

The rms volts markings on the meter face are based on the ratio between the average and effective (rms) values of a pure sine wave. The ratio of average to effective values in a true sine wave is approximately 0.9 to 1. When the meter is used to measure complex waves, the voltage indicated may not be the rms value of the signal applied. This deviation of meter indication exists because the ratios of average to effective values are usually not the same in a complex wave as in a sine wave. The amount of deviation depends on the magnitude and phase relation between the harmonics and fundamental frequency of the signal applied. Table I lists the deviation of the meter indication of a sine wave partly distorted by harmonics. As indicated in the table, harmonic content of less than 10% results in very small errors.

NOTE: The errors shown in the table are inherent in all average-responding, rms-calibrated instruments.

TABLE I

EFFECT OF HARMONICS ON VOLTAGE MEASUREMENTS

Input Voltage Characteristics	True RMS Value	Meter Indication
Fundamental = 100	100	100
Fundamental + 10% 2nd harmonic	100.5	100
Fundamental + 20% 2nd harmonic	102	100 — 102
Fundamental + 50% 2nd harmonic	112	100 — 110
Fundamental + 10% 3rd harmonic	100.5	96 — 104
Fundamental + 20% 3rd harmonic	102	94 — 108
Fundamental + 50% 3rd harmonic	112	90 — 116

METER ZERO

The meter is properly zero-set when the pointer rests over the zero calibration mark, and the instrument is in its normal operating position and is turned off. Always lightly tap the meter face as you adjust for zero to ensure accuracy.

METER INDICATION

The meter is calibrated to indicate in both dB and volts. On most AC voltmeters (600 ohms), the 0 dB range corresponds to the 1-volt range. Since this instrument is primarily a distortion analyzer, measurements are in dB (relative measurement) rather than in dBm (absolute measurement). The 0 dB range on this Analyzer corresponds to the 0.3-volt range rather than the 1-volt range.

If measurements are to be made in dBm, 10 dB must be subtracted from the METER RANGE setting. Thus 0 dB becomes −10 dBm for absolute power measurements. Zero dBm is equal to 1 milliwatt dissipated into 600 ohms. Therefore, a dBm measurement must be made across 600 ohms.

In short, when distortion and voltage measurements are being made, utilize the instrument METER RANGE and meter scale as they exist. For absolute power measurements in dBm simply subtract 10 dB from the Meter Range setting.

IN CASE OF DIFFICULTY

This section of the Manual will provide you with guide lines to help you locate and correct any difficulty you might encounter in your Distortion Analyzer. This information is divided into two sections: "General" (checks that should be made), and "Bench Testing" (procedures to help locate the problem). "Circuit Board X-Ray Views" (Page 85) and a "Schematic" diagram are also supplied to aid in troubleshooting.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to "Customer Service" information inside the rear cover of the Manual. Your Warranty is located inside the front cover.

GENERAL

1. About 90% of the kits that are returned for repair do not function properly due to poor connections and soldering. Therefore, many difficulties can be eliminated by a careful inspection of connections to make sure they are soldered as described in the "Soldering" section of the "Assembly Notes." Reheat any doubtful connections and be sure all the wires are soldered at places where several wires are connected.

2. Check the circuit boards to be sure there are no solder bridges between adjacent connections. Remove any solder bridges that may exist.

3. Be sure the transistors and diodes are in the proper location (correct part number and type number). Be sure that each transistor lead is positioned properly and has a good solder connection to the foil. Check the diodes for proper positioning of the banded end.

4. Check capacitor values carefully. Be sure the proper part is wired into the circuit at each capacitor location. For example, it would be easy to mistake a .001 μF capacitor for a 100 pF capacitor. Always check the polarity of tantalum and electrolytic capacitors to be sure the "+" lead is installed at the correct location.

5. Check each resistor carefully. It would be easy, for example, to install a 1200 Ω (brown-red-red) resistor where a 220 Ω (red-red-brown) resistor is called for. A resistor that is discolored, cracked, or shows any sign of bulging would indicate that it is faulty and should be replaced.

6. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something you have consistently overlooked.

7. Make sure coaxial cable inner and shield leads are not interchanged.

8. Check all component leads connected to the circuit boards. Make sure the leads do not extend through the circuit boards and make contact with other connections or parts.

BENCH TESTING

WARNING: Full AC line voltage is present on the rear panel (under the chassis) and the power switch when the line cord plug is connected. Be careful to avoid personal shock when you work on the Analyzer. Refer to Figure 2 in the "Illustration Booklet."

1. Trouble in the Analyzer can generally be isolated to the circuit of one of the two principle Analyzer functions: voltmeter or distortion. In order for the distortion function to operate properly, the voltmeter function must operate properly. Therefore, troubleshoot the voltmeter function first to make sure it works normally, before you attempt to locate a trouble in the distortion function.

2. Be cautious when you test the transistors and diodes. Although they have almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage and current than are other circuit components.

3. Be careful so you do not short any terminals to ground when you make voltage measurements. If the probe should slip, for example, and short out a bias or voltage supply point, it may damage one or more components.

4. When you make repairs to the Analyzer, make sure you eliminate the cause as well as the effect of the trouble. If, for example, you should find a damaged resistor, be sure you find out what caused the resistor to become damaged. If the cause is not eliminated, the replacement resistor may also become damaged when the Analyzer is put back into operation.

5. Refer to the X-Ray Views and the "Schematic" to locate the various components.

6. Use a high impedance (1 megohm or higher) voltmeter to make any voltage measurements.

7. Always check the ± 24-volt supply for proper level before you attempt to troubleshoot the Analyzer.

8. Most circuits in this instrument are AC coupled and can be easily checked with a DC voltmeter for proper voltage. A circuit failure will almost always show up as a change in DC voltage; either from a defective transistor, leaky capacitor, burned resistor, etc. Check all of the voltages carefully against the Schematic. Be sure to look for proper bias levels on the transistors. By turning the three circuit bias controls, you can effectively observe the operation of several components.

9. If you have an oscilloscope, signal tracing can be very effective. Apply a 1000 Hz signal to the input and adjust the LEVEL controls or METER RANGE switch for what **should be** a full-scale meter deflection. Then trace the signal through the circuits to discover the problem.

10. If the difficulty is in the Auto Null circuit, refer to the waveforms on the Schematic. These were produced under the following conditions after the Analyzer was manually nulled:

FUNCTION switch — SET LEVEL.
METER RANGE switch — SET LEVEL.
MODE switch — MANUAL.
FREQUENCY RANGE switch — 1k - 10k.
FREQUENCY TUNING control — 10.
Input signal — 1000 Hz; level adjusted to produce a full-scale meter deflection.

CALIBRATION

To calibrate this instrument you will need a DC voltmeter with a minimum of 1 MΩ input impedance, a sine-wave generator with 1000 Hz and 100 kHz outputs, and a nonconductive screwdriver (for trimmer adjustment). If the generator does not have a calibrated output, an AC voltmeter will be required. An oscilloscope is useful, but not necessary.

If you replace any of the photosensitive resistors or either lamp on the optical isolator circuit board, the optical isolator circuit must be realigned. Refer to "Optical Isolator Alignment" on Page 78.

Refer to Figures 1 and 2 (in the "Illustration Booklet") for the location of the internal controls for calibration.

Refer to Figure 3 (in the "Illustration Booklet") and preset the front panel controls and switches as follows:

MODE switch — MANUAL.
METER RANGE switch — SET LEVEL (.3 VOLTS).
LEVEL switch — MAX.
LEVEL control — POWER OFF.
FREQUENCY RANGE switch — 10k - 100k.
FUNCTION switch — VOLTMETER.
FREQUENCY TUNING control — 100.
BALANCE COARSE control — Center of rotation.
BALANCE FINE control — Center of rotation.
METER ZERO screw — Center meter pointer over "0" mark.

WARNING: When the line cord is connected, dangerous AC voltage is present on the rear panel and switch SW6/R32. Refer to Figure 2.

( ) Remove the screws that secure the top and bottom panels, but do not remove the panels.

( ) Plug the line cord plug into an AC receptacle.

( ) Turn the Analyzer on and rotate the LEVEL control fully clockwise. Allow the Analyzer 30 minutes to warm up.

( ) Remove the top panel and connect the DC volt-meter input to the collector of transistor Q203 on the meter amplifier circuit board. Then adjust BIAS ADJ control R202 for +7 VDC.

( ) Turn the Analyzer over, and remove the bottom panel.

( ) Loosen the two screws that hold the bottom shield and remove the bottom shield.

( ) Connect the DC voltmeter input to the collector of transistor Q103 on the bridge amplifier circuit board. Adjust BIAS ADJ control R108 for +3.5 volts.

( ) Reinstall the bottom shield and tighten the two screws.

( ) Reinstall the bottom panel (no screws) and turn the Analyzer over.

( ) Connect the DC voltmeter input to the collector of transistor Q108 on the null amplifier circuit board. Adjust BIAS control R125 for −15.5 volts.

NOTE: Because of the sensitivity of the meter amplifier circuit, the meter will always display a small residual voltage. This will not affect the accuracy of readings above the residual level.

( ) Set the output of your sine-wave generator for 1000 Hz at 0.3 volts rms, and connect it to the INPUT binding posts of the Analyzer.

( ) Adjust the meter pointer so it is directly over the "3" on the upper meter scale, with CALIBRATE control R205, on the meter amplifier circuit board.

( ) Turn the METER RANGE switch to 1 VOLT. Note the meter indication on the 0 - 10 scale.

( ) Turn the METER RANGE switch to .3 VOLTS.

( ) Set the output of your generator for 100 kHz. If necessary, readjust the generator output so the Analyzer meter still indicates "3" on the 0 - 3 scale.

( ) Turn the METER RANGE switch to 1 VOLT.

( ) With a nonconductive alignment tool, adjust trimmer C2, on the METER RANGE switch (SW4), for a meter reading identical to the reading you noted previously.

( ) Turn the METER RANGE switch to SET LEVEL.

( ) Turn the FUNCTION switch to SET LEVEL.

( ) Turn the Analyzer over and remove the bottom panel.

( ) Adjust the output level of your generator so the Analyzer meter indicates 10 on the 0 - 10 scale.

( ) Turn the LEVEL switch to MID.

( ) Adjust trimmer C4 for a meter reading of 1 on the **0 - 10 scale**.

( ) Adjust the output level of your generator so the Analyzer meter indicates 10 on the 0 - 10 scale.

( ) Turn the LEVEL switch to MIN.

( ) Adjust trimmer C6 for a meter reading of 1 on the 0 - 10 scale.

( ) Turn the LEVEL switch to MAX.

( ) Repeat the previous seven steps until there is no further need for adjustment.

( ) Adjust the output level of your generator so the Analyzer meter indicates "10" on the 0 - 10 scale.

( ) Reinstall the bottom panel and secure it with the six screws previously removed. Then turn the Analyzer over.

NOTE: If you have an oscilloscope, connect the Analyzer output to the vertical input, and the generator output to the external horizontal input (X-Y operation). This will allow you to observe the frequency nulling process.

( ) Lay the top panel on the Analyzer so the interior is covered from the rear of the Analyzer up to the front of the variable capacitor.

( ) Turn the FUNCTION switch to Distortion.

NOTE: In the following steps, you will adjust the bridge circuit for a null condition (as indicated by the meter).

( ) With the generator still adjusted for 100 kHz, adjust the FREQUENCY TUNING control on the Analyzer for null (minimum meter deflection).

( ) Adjust trimmer C120, on the bridge amplifier circuit board, for null.

( ) Repeat the two previous steps until there is no further reduction in the meter display. It will be necessary to increase the sensitivity of the meter, with the Meter Range switch, as you reach null. NOTE: As your adjustments become more critical, stray capacitance from your hand and the trimmer adjusting tool will affect the trimmer adjustment. Therefore, when you adjust the trimmer: turn the screw a small amount, remove the tool, slide the top cover up to the front of the Analyzer, and observe the new meter indication.

( ) Adjust the COARSE and FINE BALANCE controls for null.

( ) Readjust the FREQUENCY TUNING control and trimmer C120 for null.

( ) Repeat the two previous steps until there is no further reduction in the meter display. NOTE: The total harmonic distortion of the generator and the Analyzer will determine the final meter indication.

( ) Reinstall the top panel with the six screws previously removed.

( ) Move the MODE switch to AUTO. After the meter settles down, it should indicate a value approximately equal to the value in the previous step. NOTE: With very careful adjustment, it is possible to manually null the Analyzer more accurately (by a **very** small percentage) than with the auto null circuits.

( ) Move the MODE switch to MANUAL.

( ) Turn the METER RANGE switch to SET LEVEL.

( ) Turn the FUNCTION switch to SET LEVEL.

( ) Disconnect the generator and oscilloscope.

( ) Turn the Analyzer off and disconnect the line cord plug.

This completes basic calibration.

OPTICAL ISOLATOR ALIGNMENT

To align the isolator circuit, a number of wires must be removed. Refer to Figure 1 and remove the following wires.

On the optical isolator circuit board:

( ) Yellow wire from hole A.

( ) Red wire from hole B.

( ) White-gray wire from hole C.

( ) Green wire from hole D.

( ) White-brown from hole E.

On the null amplifier circuit board:

( ) White wire from hole AA.

( ) Violet wire from hole FF.

( ) Position the seven loose wires up away from the circuit.

( ) Turn the Analyzer on. All of the functions will operate in a normal manner except the auto null mode.

In the following steps, you will measure and adjust the resistance of the five photo resistors on the optical isolator circuit board. Figure 4 shows the lead location for each resistor. To perform the adjustment operation:

1. Measure the resistance of a photo resistor.
2. If the resistance is incorrect, remove the resistor housing top (turn it 1/4-turn counterclockwise and pull) and reposition the resistor body (nearer the lamp to decrease the resistance, away from the lamp to increase the resistance). NOTE: You can move the photo resistor vertically or horizontally to make this adjustment.
3. Reinstall the housing top and measure the resistance again. NOTE: You may have to reposition the resistor several times before you obtain the correct resistance. Always install the housing top before you measure the resistance.

Adjust the resistance of the following five photo resistors within the specified values.

( ) R501 — 140 kΩ to 160 kΩ.

( ) R502 — 14 kΩ to 20 kΩ.

( ) R503 — 140 kΩ to 160 kΩ.

( ) R504 — 14 kΩ to 20 kΩ.

( ) R505 — 28 kΩ to 32 kΩ.

( ) Turn the Analyzer off.

Connect the two wires you previously disconnected, to the null amplifier circuit board as follows:

( ) White wire to hole AA (S-1).

( ) Violet wire to hole FF (S-1).

Connect the five wires from switch SW3 to the optical isolator circuit board as follows:

( ) Yellow wire to hole A (S-1).

( ) Red wire to hole B (S-1).

( ) White-gray wire to hole C (S-1).

( ) Green wire to hole D (S-1).

( ) White-brown wire to hole E (S-1).

( ) Turn the Distortion Analyzer on and connect a 100 kHz signal.

( ) Carefully adjust the Analyzer to measure the distortion of the signal, in the MANUAL MODE.

( ) Move the MODE switch to AUTO. After the meter settles down, it should indicate a value approximately equal to the value in the previous step. NOTE: At this sensitivity level it is very difficult, but possible, to manually adjust this instrument more accurately than with the auto null circuits, by a very small percentage.

( ) Move the MODE switch to MANUAL.

( ) Disconnect the signal.

( ) Turn the Analyzer off.

This completes alignment of the optical isolator circuit.

SPECIFICATIONS

Frequency Range	5 Hz to 100 kHz in 5 ranges: 5 - 10 Hz. 1 - 10 kHz. 10 - 100 Hz. 10 - 100 kHz. 100 - 1000 Hz.
Distortion	0.3% to 100% full scale in 6 ranges with a 1 - 3 - 10 sequence.
Residual Distortion	0.03% or less.
Input Impedance	1 MΩ/70 pF maximum.
Required Input Level	316 mV rms for distortion measurements.
Voltmeter	1 mV to 300 V in 12 ranges with a 1 - 3 - 10 sequence.
Accuracy	5% of full scale.
Output	100 mV for full scale meter deflection.
Power Requirements	100 - 135V, 50/60 Hz, 12 watts. (200 - 270V, switch selected.)
Dimensions	15″ wide, 11.5″ deep, 5.38″ high. (38.1 cm wide, 29.2 cm deep, 13.6 cm high.)
Weight	12 lbs. (5.41 kgs.)

The Heath Company reserves the right to discontinue products and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.

CIRCUIT DESCRIPTION

THEORY OF OPERATION

The Harmonic Distortion Analyzer is composed of five primary circuits: an impedance converter, a rejection amplifier, a meter amplifier, an auto null amplifier, and a power supply. The impedance converter provides a low-noise input circuit with a high input impedance. The rejection amplifier removes the fundamental frequency of the input signal. The meter amplifier amplifies the signal from the rejection amplifier for display on the front panel meter and supplies an output to visually monitor the meter signal. The auto null amplifier has two control loops consisting of phase detectors, lamp drivers, lamps, and photocells to regulate fine tuning and balance in the rejection amplifier. Two integrated circuits in the power supply regulate power supply voltage.

DISTORTION MEASUREMENT

For distortion measurement, the input signal is applied to the impedance converter through the input rejection amplifier attenuator. The attenuator provides three continuously variable decades of signal attenuation. The impedance converter provides unity gain between the input and the rejection amplifier.

The rejection amplifier consists of a bridge amplifier, Wien bridge, and null amplifier. With the Function switch in the SET LEVEL position, the Wien bridge circuit is grounded. The signal to the rejection amplifier is then adjusted for a full-scale meter reading or 0 dB with the Level switch and control. With this reference level set, distortion can be accurately measured in percentage or dB. When the Function switch is set to DISTORTION, the Wien bridge acts as an interstage coupling network between the bridge amplifier and null amplifier. The Wien bridge is tuned and balanced to reject the fundamental frequency of the input signal. Two automatic control loops consisting of phase detectors, lamp drivers, lamps and photoresistors in the auto null amplifier provide fine tuning and balance in the auto mode of operation.

The remaining frequency components from the Wien bridge are amplified by the null amplifier and are applied to the meter amplifier through the post attenuator. This signal is also coupled back to the bridge amplifier and serves to narrow the rejection response of the Wien bridge. The post attenuator is used to limit the signal level to the metering circuit to 1 mV for full-scale deflection. The metering circuit provides a quantitative indication of the distortion level of the input signal. Output terminals are provided to visually monitor the distortion components with an oscilloscope.

VOLTAGE MEASUREMENT

In the voltage mode of operation, the input signal is applied to the impedance converter through the input voltage attenuator. The attenuator provides a 1:1 or 1000:1 attenuation. It works in conjunction with the post attenuator to provide all of the required meter ranges. The output of the impedance converter is coupled to the rejection amplifier. With the Function switch in the VOLTMETER position the Wien bridge circuit is grounded, and the input signal is coupled through the bridge amplifier, null amplifier, and post attenuator to the meter amplifier. The signal level is then indicated on the meter and coupled to the output terminals.

DETAILED CIRCUIT DESCRIPTION

The input signal is applied to the impedance converter circuit through the input voltage attenuator (R1 and R2) in voltage operation, and the input rejection amplifier attenuator (R3 through R5) in distortion operation. Capacitor dividers C2 and C3 and C4 through C6 in the attenuators provide high-frequency division to keep the frequency response flat.

Instrument induced distortion of the input signal is minimized by keeping the response of the impedance converter linear. Direct coupling from the collector of Q102 to the emitter of Q101 results in unity gain from the impedance converter. A Darlington configuration is used at Q101 to minimize instrument induced distortion while maintaining high input impedance.

REJECTION AMPLIFIER

The rejection amplifier circuit consists of the bridge amplifier (Q103 through Q105), the Wien bridge resistive leg and reactive leg, and the null amplifier (Q106 through Q108). The Wien bridge auto-control circuits will be described under "Auto Null Amplifier."

The signal from the impedance converter is applied to the bridge amplifier. Negative feedback from the junction of R115 and R117 is applied to the junction of R109 and C106 to establish the operating point for Q103. Negative feedback from the emitter of Q105 is applied to the emitter of Q103 to stabilize the bridge amplifier. The bridge amplifier is designed for high open-loop gain and low closed-loop gain to minimize instrument-induced distortion.

In distortion measurement, the Wien bridge circuit is used as a rejection filter for the fundamental frequency of the input signal. With Function switch SW5 in DISTORTION, the Wien bridge is connected as an interstage coupling network between the bridge amplifier and null amplifier. The bridge is tuned to the fundamental frequency of the input signal by setting Frequency Range switch SW3 for the applicable frequency range, and tuning capacitors C118 and C119. The bridge circuit is balanced by adjusting Coarse and Fine Balance controls R6 and R7. In the Automatic mode, fine tuning and balance are accomplished by photoresistors which are in the resistive and reactive legs of the Wien bridge. The error signals for driving the photoresistors are derived by detecting the bridge output, using the input signal as a reference.

When the Wien bridge circuit is tuned and balanced, the voltage and phase of the fundamental, which appears at the junction of the series resistive leg (R16, R11, R13, or R15, and C118) and the shunt reactive leg (R25, R20, R22, or R24, and C119) are the same as at the midpoint of the resistive leg between R116 and R120. When these two voltages are equal and in phase, the fundamental frequency will not appear at the drain of field-effect transistor Q106. For frequencies other than the fundamental, the reactive leg of the Wien bridge offers various degrees of attenuation and phase shift which cause a voltage at the output points of the bridge. This difference voltage between the reactive leg and resistive leg is amplified by the null amplifier.

The null amplifier circuit consists of three stages of amplification, Q106 through Q108. The first stage is a field-effect transistor which amplifies the difference signal between the gate and the source. The signal from the drain is applied to the two-stage feedback amplifier, Q107 and Q108. The output of Q108 is coupled to the meter circuit by the post attenuator. Negative feedback from the output of the null amplifier is applied to the bridge amplifier to narrow the frequency rejection characteristic of the rejection amplifier.

When Function switch SW5 is set to the SET LEVEL or VOLTMETER position, the junction of the series and shunt reactive branches of the Wien bridge is connected to circuit ground through R127. This disables the frequency rejection characteristic of the bridge circuit. With the bridge circuit thus disabled, the rejection amplifier circuit couples the applied signal to the meter amplifier through the post attenuator.

BETWEEN
SW5
& BRIDGE AMP PC

METER AMPLIFIER

The meter amplifier consists of the post attenuator, the meter amplifier circuit, and the meter rectifier circuit.

Post attenuator R26 through R31 is a resistive network which attenuates the input signal in 10 dB steps. The attenuator is used in conjunction with either of the input attenuators for appropriate meter range selection.

The meter amplifier circuit is a five-stage amplifier circuit, Q201 through Q205, which develops the current for full-scale meter deflection. Negative DC feedback from the emitter of Q204 is applied to the base of Q201 to stabilize the DC operating point of the meter amplifier circuit, and to minimize the tendency for DC drift due to ambient temperature changes. R217 and ZD201 are electrically in the circuit only when the meter amplifier is overloaded. When the voltage on the emitter of Q205 becomes abnormally large, ZD201 breaks down and provides a lower resistance charging path for C201. This reduces the transient recovery time of the meter amplifier. Negative AC feedback is applied from the collector of Q205 to the emitter of Q201. This feedback is used to ensure flat frequency response, to improve linearity, and to reduce the effect of variation in transistor parameters with environmental changes.

The meter rectifier circuit is connected in a bridge-type configuration with a diode in each upper branch and a DC milliammeter connected across the midpoints of the bridge. The meter amplifier supplies the meter with current for full-scale deflection and develops a voltage across the calibration network, which closes the AC feedback loop. C211 and C212 are used as coupling capacitors for the AC feedback loop, output signal to the Output connector, and the bridge error signal to the auto null circuits. The mechanical inertia of the meter and C210 prevent the meter from responding to individual current pulses. Therefore, the meter indication corresponds to the average value of the current pulses rather than the peak value. The meter is calibrated to indicate the rms value of a sine wave.

AUTO NULL AMPLIFIER

In the Automatic mode, fine tuning and balancing are accomplished by photo-resistors in the resistive and reactive legs of the Wien bridge circuit. Error signals for driving the photo-resistors are derived by detecting the bridge output and using the input signal as a reference.

When the Wien bridge is not tuned exactly to the frequency to be nulled, a portion of the fundamental frequency will appear at the bridge output. The phase of this signal depends on which leg of the bridge is not tuned, or on the relative errors in tuning if neither is tuned correctly. The magnitude of the signal is proportional to the magnitude of the tuning error of either or both legs of the bridge.

Bridge output (error signal) is detected in the resistive control loop using the input signal as the reference. Error signals in phase or 180° out of phase with the reference develop a voltage that is used to vary the resistance in the resistive leg of the bridge, to tune it to the correct null position. Error signals 90° out of phase do not develop any voltage in the resistive detector.

The reactive control loop shifts the input signal 90° before it is used as the reference signal. Thus, error signals 90° and 270° out of phase with the reference develop a voltage in the reactive detector.

The result is that two control loops derive information from a common source and develop two independent control signals for nulling the two legs of the Wien bridge. These control voltages are used to vary the brilliance of lamps, which in turn causes resistance changes in photo-resistors that form part of the Wien bridge.

In the Automatic mode of operation, the reference voltage is coupled from the output of the impedance converter to buffer amplifier Q307. The reference voltage is amplified and clipped by Q308 and Q309, producing a square wave, which is coupled to the base of detector Q304. The error from the meter amplifier is coupled to buffer Q301. It is amplified by Q302 and Q303, and coupled to the collector of detector Q304. When Q304 is turned off, the error signal from Q302 cancels the error signal from Q303 (signals are of equal amplitude, but opposite phase). However, when the positive half of the reference signal gates Q304 on, the output from the collector of Q303 is shorted to ground. Thus, the error signal from the collector of Q302 will be coupled through the filter network to the base of amplifier Q305. If the signal from Q302 is in phase with the reference, the positive half of the signal will be passed, and if it is out of phase, the negative half will be passed.

Any error voltage at the base of Q305 is amplified by Q305 and lamp driver Q306. This will change the brilliance of lamp L501, which will vary the resistance of photo-resistor R505 in the direction necessary to balance the resistive leg of the bridge.

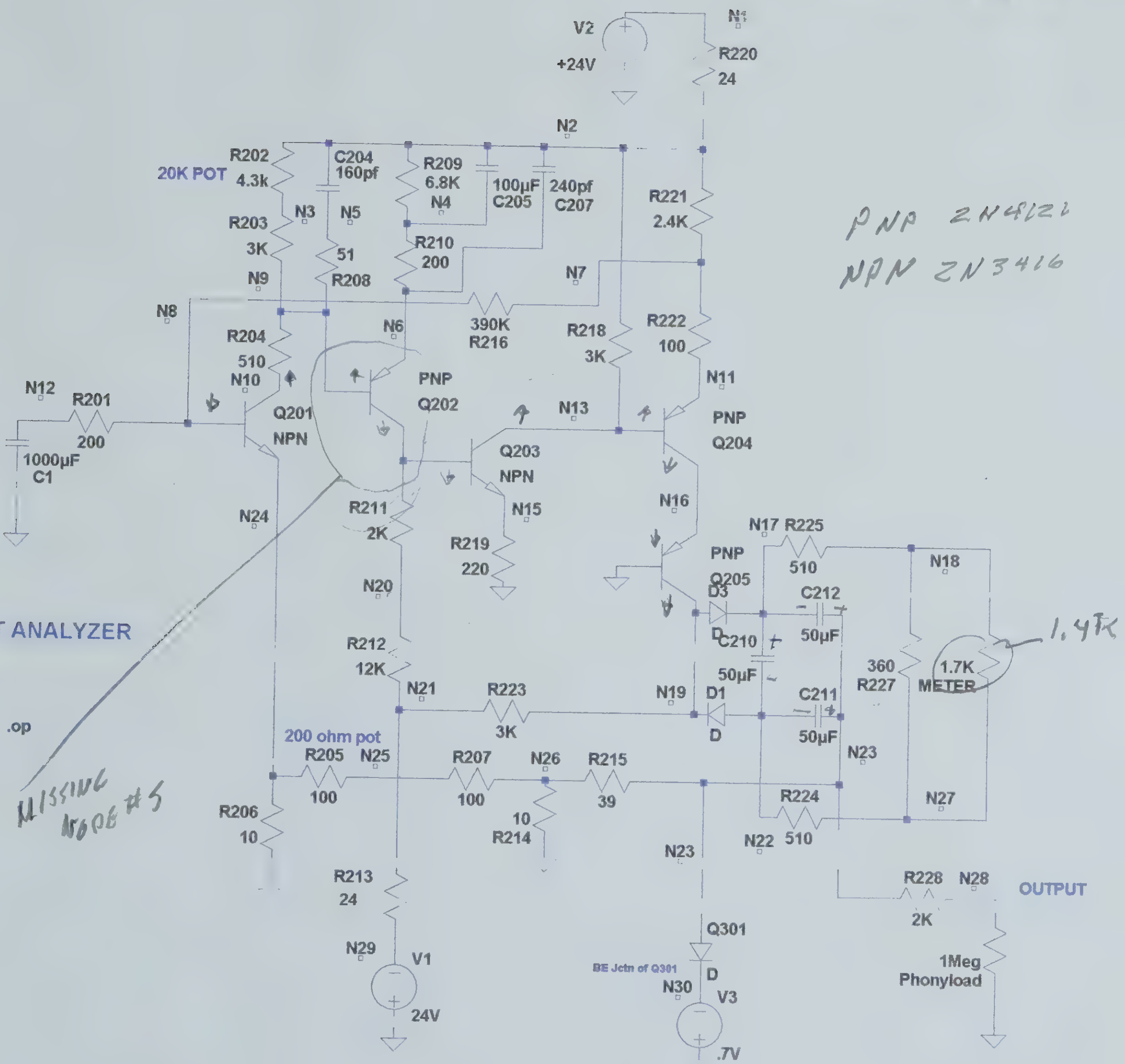
Operation of the reactive control loop is similar to that of the resistive control loop. 90° phase-lag amplifier, Q315 and Q316, shifts the reference signal. This makes detector Q312 sensitive to components of the bridge error signal that are 90° and 270° out of phase. The output of lamp driver Q314 controls the brilliance of lamp L502. This varies the resistance of photo-resistors R501, R502, R503, and R504 to balance the reactive leg of the bridge.

In the Manual mode of operation, a constant bias voltage is applied to the bases of Q305 and Q313. This maintains a constant lamp brilliance so only the manual tuning and balance controls affect the Wien bridge.

POWER SUPPLY

The power supply circuit consists of a power transformer, diodes to rectify the AC voltage, capacitors to filter the rectified voltage, and two integrated circuit voltage regulators. IC401 regulates the positive supply voltage while IC402 regulates the negative supply voltage. A voltage divider, connected between the two supply outputs and the control input of each regulator, insures that the two supplies track each other and maintain a constant output at 24 volts DC.

MATCHES .OP PRINTOUT 7/10/16



PNP 2N4122
NPN 2N3416

HEATHKIT IM5258 HARMONIC DIST ANALYZER

Meter Amp Ckt

.op

--- K:\Heath Dist Anal-SPICE\Meter Amp Schematic.asc ---

Z

MATCHES SCHEMATIC 7/10/16

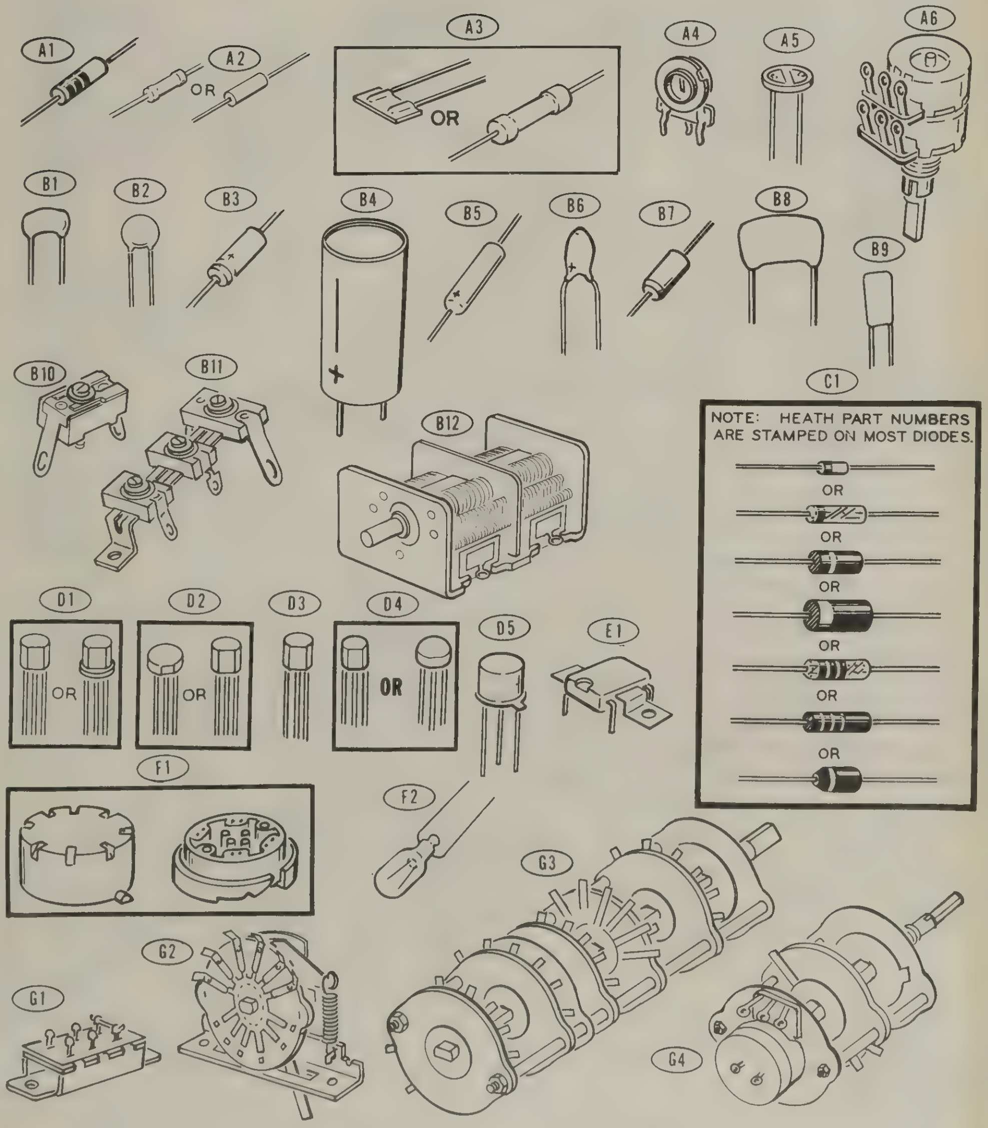
```
       --- Operating Point ---

V(n010):         8.36863          voltage
V(n008):         0.810346         voltage
V(n024):         0.0185644        voltage
V(n014):         2.06026          voltage
V(n009):         9.37384          voltage
V(n006):         10.1647          voltage
V(n013):         7.04744          voltage
V(n015):         1.24153          voltage
V(n016):         0.821251         voltage
V(n011):         7.86895          voltage
V(n019):         -5.33096         voltage
V(n012):         0.810346         voltage
V(n003):         15.2297          voltage
V(n005):         9.37384          voltage
V(n004):         10.5492          voltage
V(n002):         23.6231          voltage
V(n020):         -1.63518         voltage
V(n021):         -23.8078         voltage
V(n007):         8.49723          voltage
V(n029):         -24      voltage
V(n001):         24       voltage
V(n022):         -5.33077         voltage
V(n017):         -5.33077         voltage
V(n023):         -0.0458513       voltage
V(n025):         0.00513782       voltage
V(n026):         -0.00828876      voltage
V(n027):         -5.33077         voltage
V(n018):         -5.33077         voltage
V(n030):         -0.7     voltage
V(n028):         -0.0457598       voltage
Ic(Q205):        -0.00615896      device_current
Ib(Q205):        -6.15896e-005    device_current
Ie(Q205):        0.00622055       device_current
Ic(Q204):        -0.00622055      device_current
Ib(Q204):        -6.22055e-005    device_current
Ie(Q204):        0.00628276       device_current
Ic(Q202):        -0.0019036       device_current
Ib(Q202):        -1.9036e-005     device_current
Ie(Q202):        0.00192263       device_current
Ic(Q203):        0.00558744       device_current
Ib(Q203):        5.58744e-005     device_current
Ie(Q203):        -0.00564331      device_current
Ic(Q201):        0.001971         device_current
Ib(Q201):        1.97099e-005     device_current
Ie(Q201):        -0.00199071      device_current
I(C1):   8.10346e-016    device_current
I(C210):         -4.44089e-032    device_current
I(C211):         2.64246e-016     device_current
I(C212):         2.64246e-016     device_current
I(C207):         3.23002e-021     device_current
I(C205):         1.30739e-015     device_current
I(C204):         2.27989e-021     device_current
I(Q301):         0.000963188      device_current
I(D3):   -2.64239e-016   device_current
I(D1):   2.64783e-016    device_current
I(Phonyload):    4.57598e-008     device_current
I(R228):         4.57598e-008     device_current
I(Meter):        -5.22458e-019    device_current
I(R227):         -2.46716e-018    device_current
I(R225):         0        device_current
I(R224):         0        device_current
```

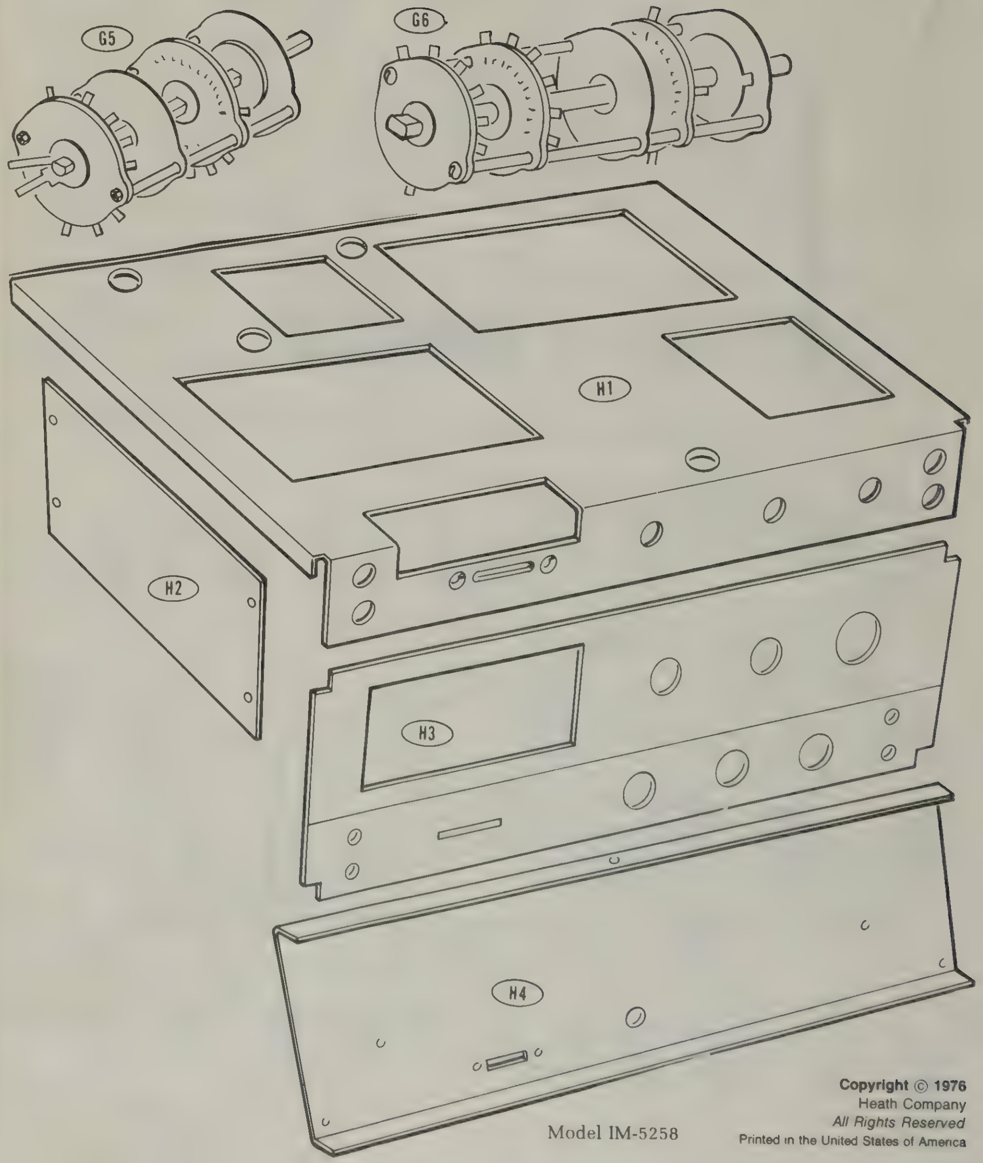
```
I(R214):         0.000828876     device_current
I(R215):         -0.000963142    device_current
I(R207):         -0.000134266    device_current
I(R205):         -0.000134266    device_current
I(R216):         1.97099e-005    device_current
I(R223):         0.00615896      device_current
I(R220):         0.0157023       device_current
I(R213):         0.00800668      device_current
I(R206):         -0.00185644     device_current
I(R218):         -0.00552523     device_current
I(R221):         -0.00630247     device_current
I(R222):         -0.00628276     device_current
I(R202):         -0.00195196     device_current
I(R219):         -0.00564331     device_current
I(R212):         -0.00184772     device_current
I(R211):         -0.00184772     device_current
I(R209):         -0.00192263     device_current
I(R210):         -0.00192263     device_current
I(R208):         0       device_current
I(R203):         -0.00195196     device_current
I(R204):         -0.001971       device_current
I(R201):         8.10463e-016    device_current
I(V3):   -0.000963188    device_current
I(V2):   -0.0157023      device_current
I(V1):   -0.00800668     device_current
```

ILLUSTRATION BOOKLET

PARTS PICTORIAL



NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES.



Model IM-5258

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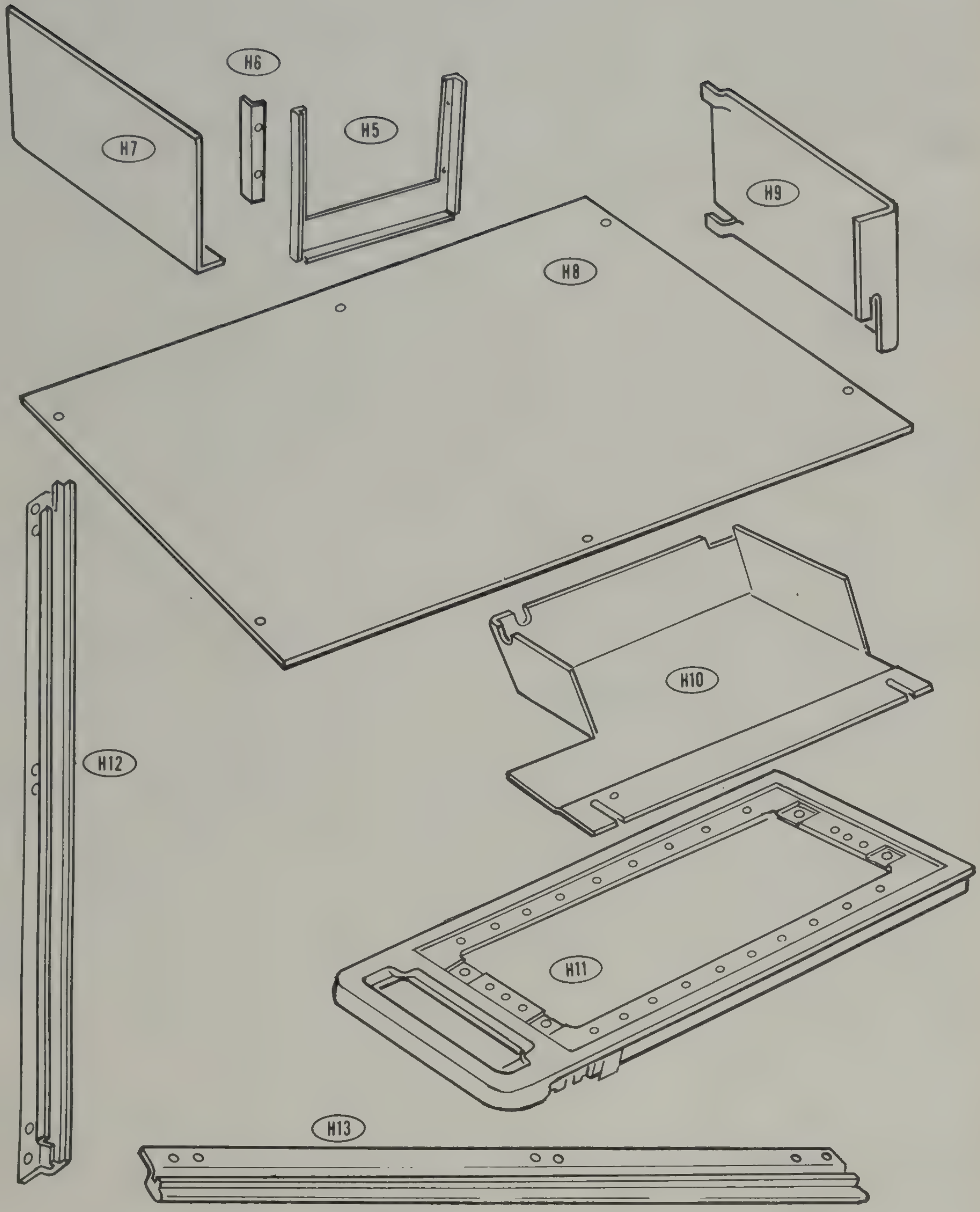
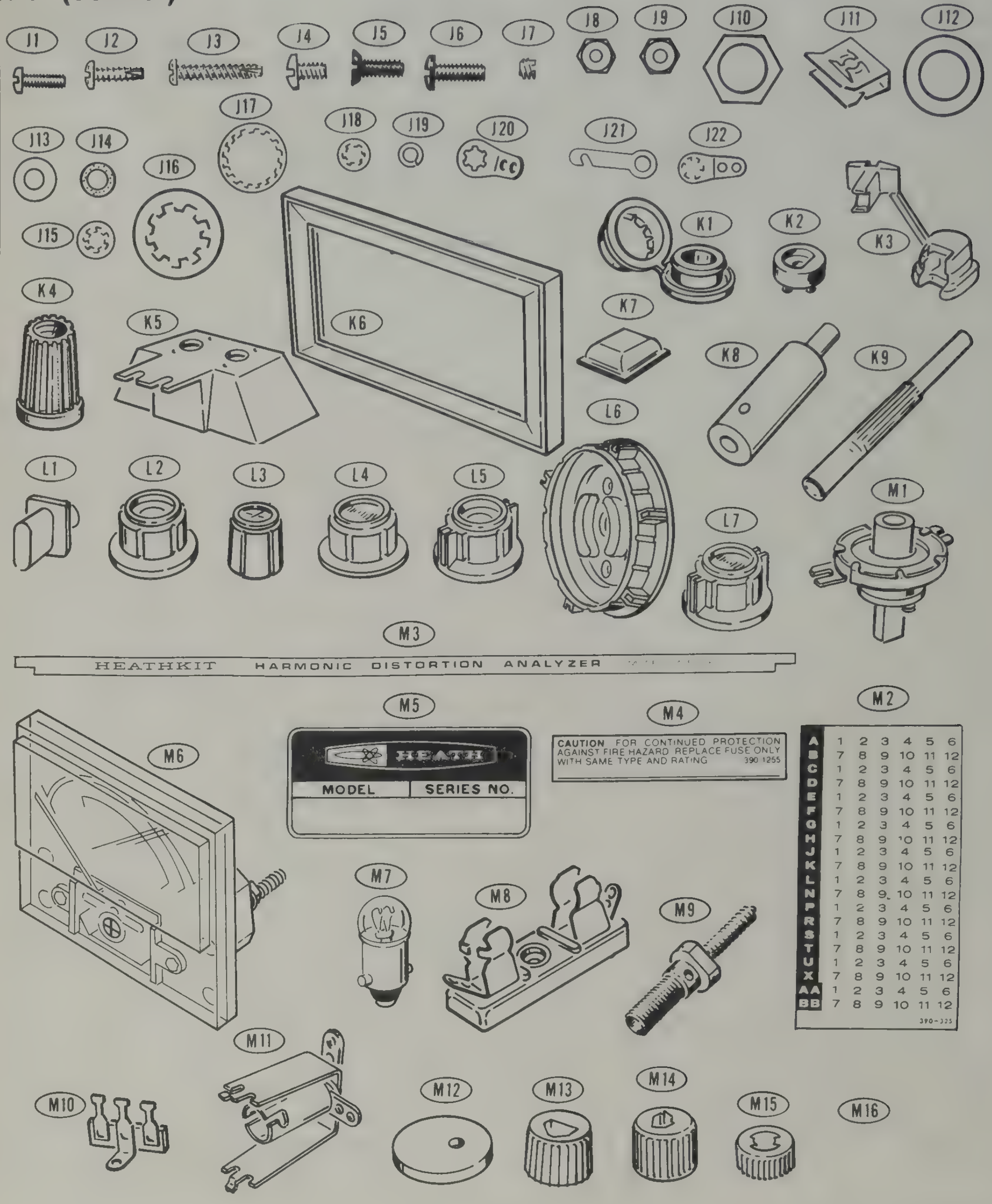
Parts Pictorial (cont'd.)




J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
J11
J12
J13
J14
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J16
J17
J18
J19
J20
J21
J22
K1
K2
K3
K4
K5
K6
K7
K8
K9
L1
L2
L3
L4
L5
L6
L7
M1
M3
HEATHKIT HARMONIC DISTORTION ANALYZER
M5
HEATH
MODEL
SERIES NO.
M4
CAUTION FOR CONTINUED PROTECTION AGAINST FIRE HAZARD REPLACE FUSE ONLY WITH SAME TYPE AND RATING 390 1255
M2
A B C D E F G H J K L N P R S T U X AA BB
1 2 3 4 5 6
7 8 9 10 11 12
390-325
M6
M7
M8
M9
M10
M11
M12
M13
M14
M15
M16

FIGURE A

When you install electrolytic capacitors, be sure you match the positive (+) marking on the capacitor with the positive (+) marking on the circuit board. NOTE: The capacitor may be marked only with a negative (−) mark.

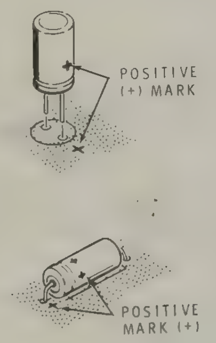


FIGURE B

NOTE: When you install ceramic capacitors, do not push the insulated portion of the leads into the circuit board holes. This could make it difficult to solder the leads to the foil.

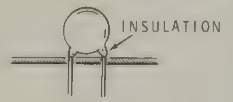


FIGURE C

NOTE: When you install tantalum capacitors, match the positive (+) marking or red end of the capacitor with the positive (+) marking on the circuit board.

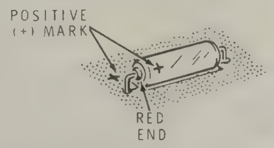


FIGURE D

When you install tantalum capacitors, always match the positive (+) mark or dot on the capacitor with the positive (+) mark on the circuit board.

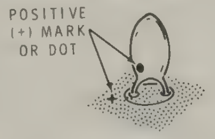


FIGURE E

When you install tantalum capacitors, always match the positive (+) mark on the capacitor with the positive (+) mark on the circuit board.

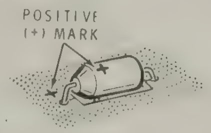
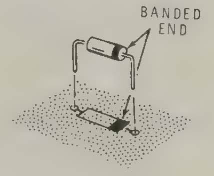


FIGURE F

NOTE: When you install a diode always match the band on the diode with the band mark on the circuit board. A DIODE WILL NOT WORK IF IT IS INSTALLED BACKWARDS.



NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES.

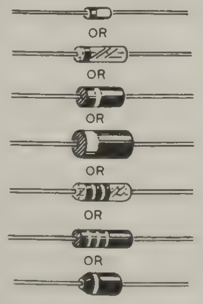
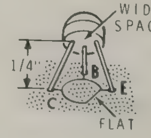


FIGURE G

NOTE: Locate the transistor part number in the following chart; then refer to the indicated illustration(s) to see how to mount the transistor. When you install a transistor, first align the flat, wide space, or tab of the transistor, with reference to the flat or tab outline on the circuit board as the illustration shows. Then insert the correct transistor leads into the corresponding marked holes. Position the transistor 1/4" above the circuit board, solder the leads to the foil, and cut off the excess lead lengths.

HEATH PART NO.	MOUNTING ILLUSTRATION
417-93	A, H
417-94	B, K
417-222	B, K
417-235	C, D
417-886	E
417-283	H, J
417-878	F

ILLUSTRATIONS

Ⓐ


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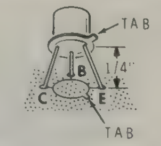

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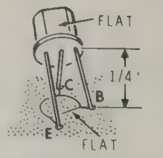

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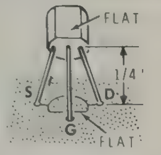

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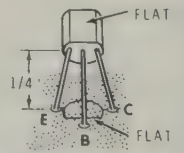

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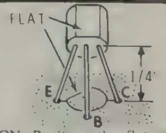
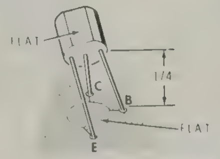


CAUTION: Position the flat of this transistor opposite the flat on the circuit board.

Ⓚ


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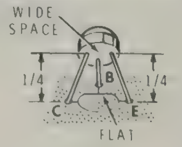

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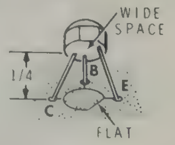
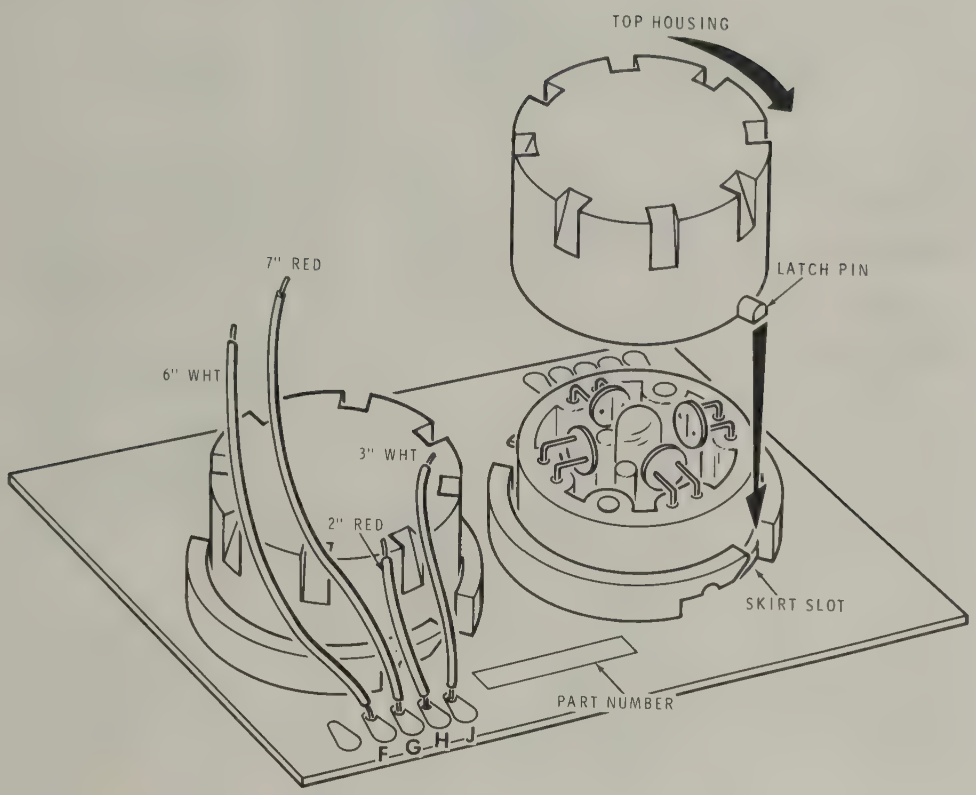
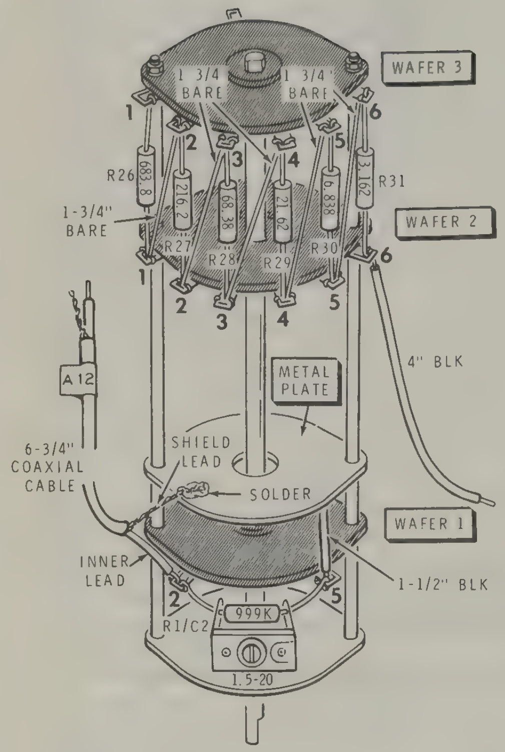
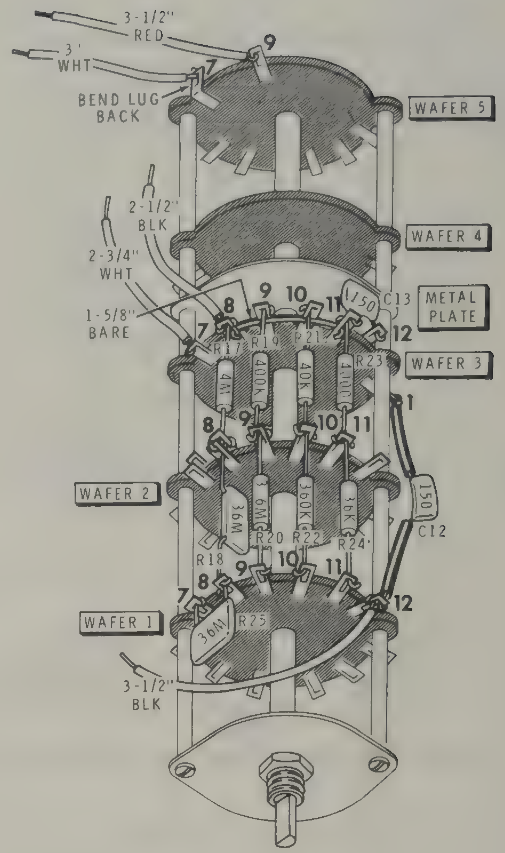




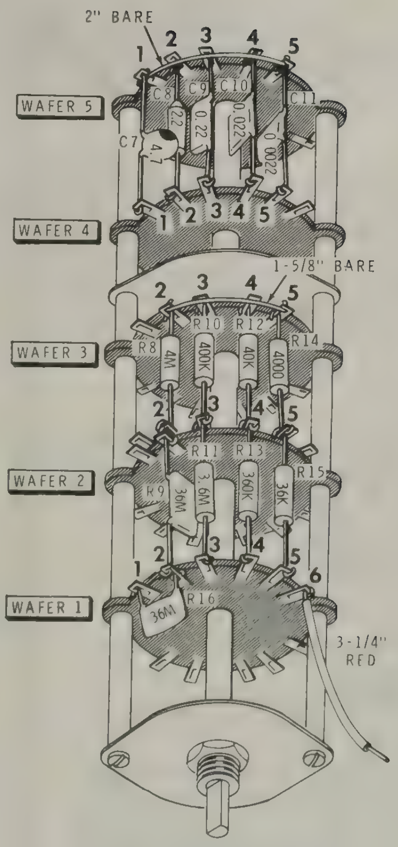
PICTORIAL 6-2



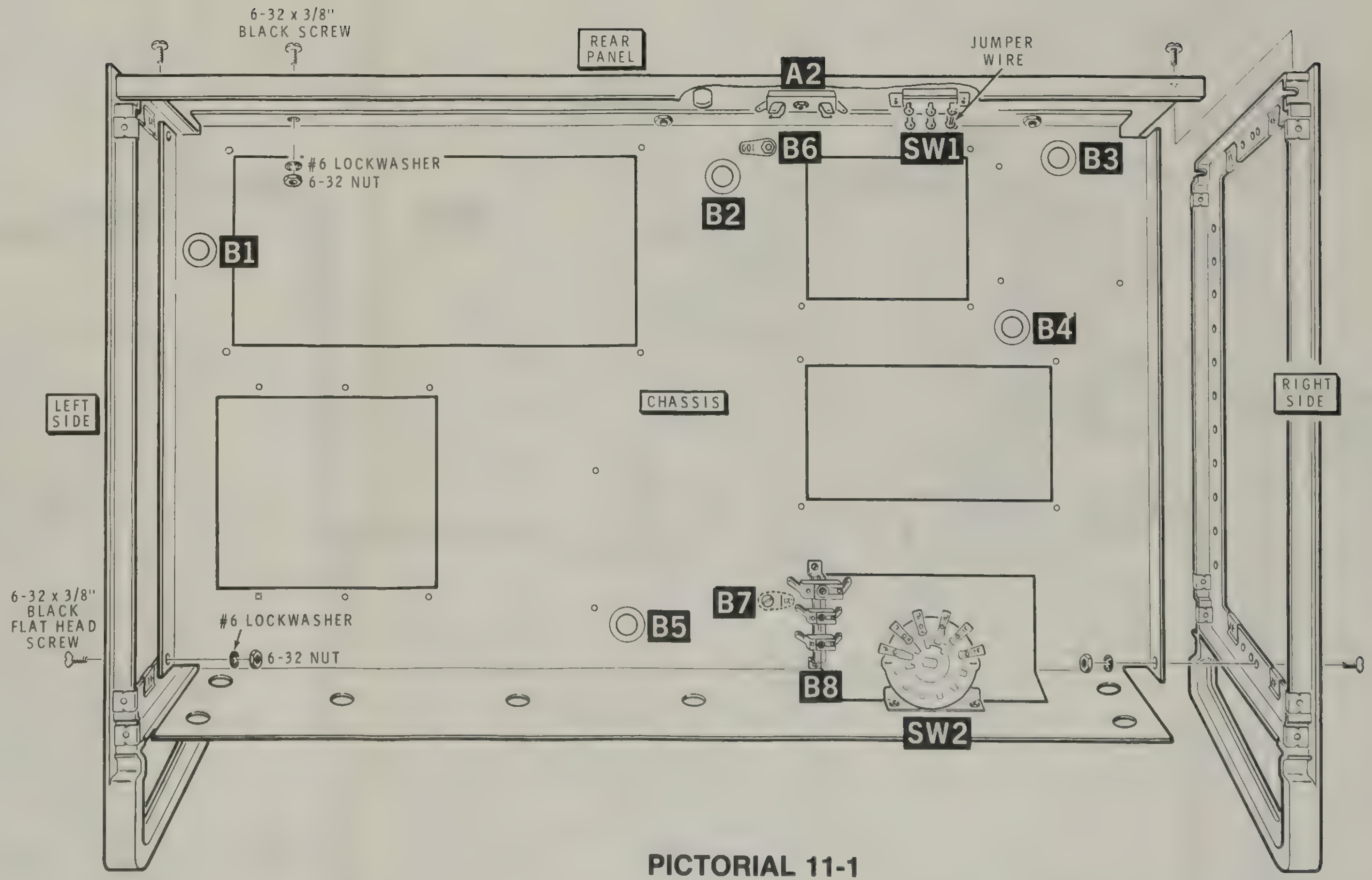
PICTORIAL 7-1



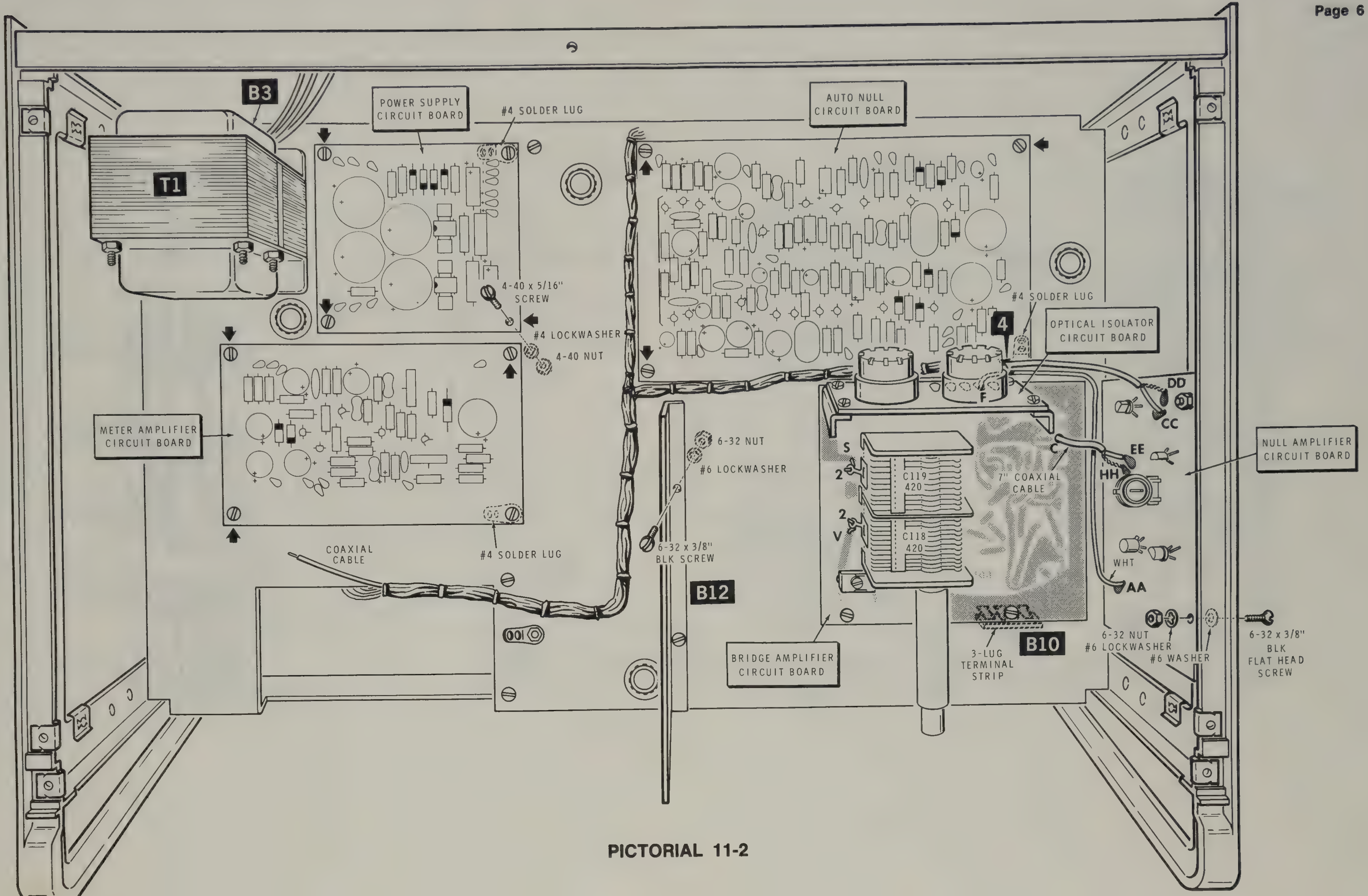
PICTORIAL 8-1



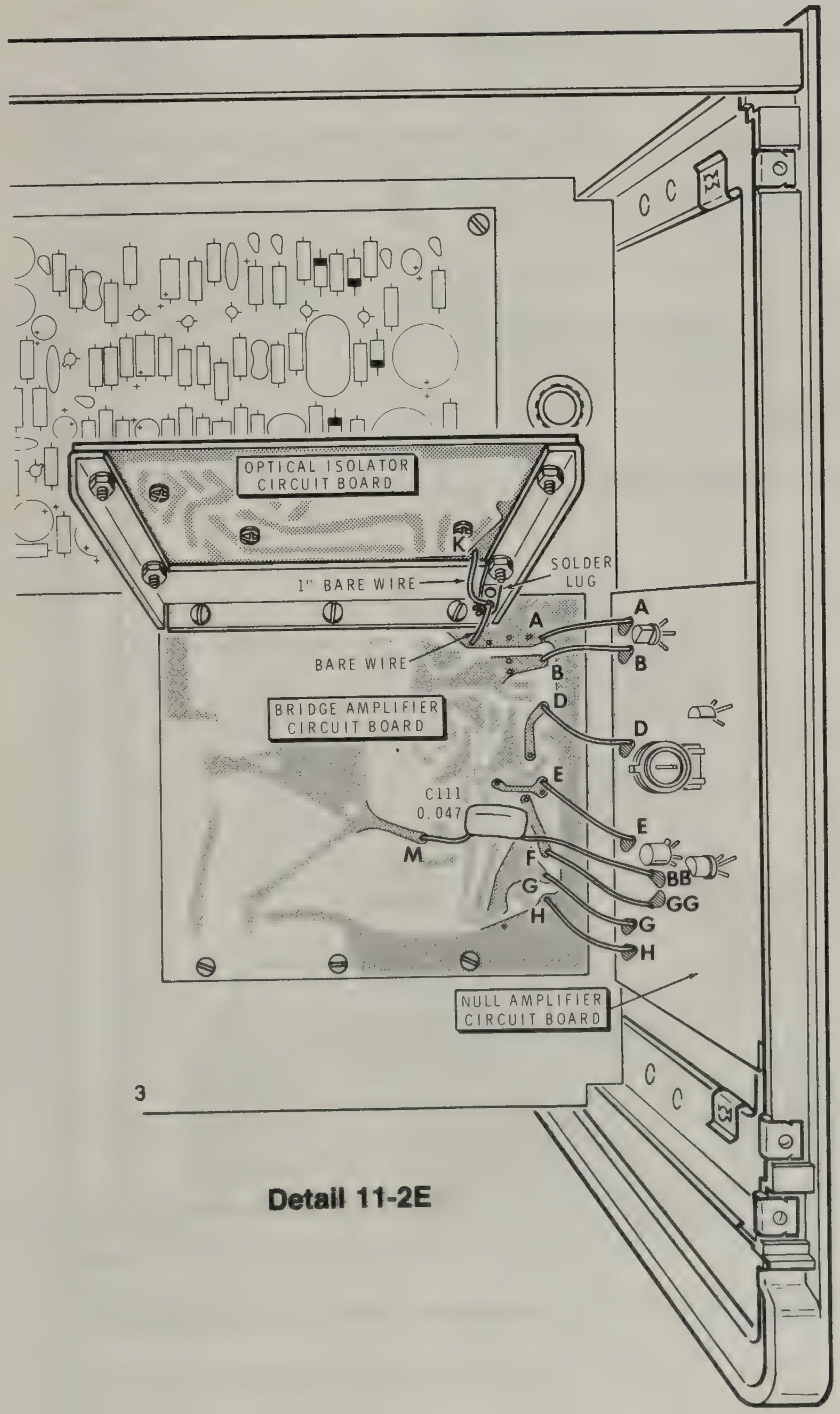
PICTORIAL 8-2



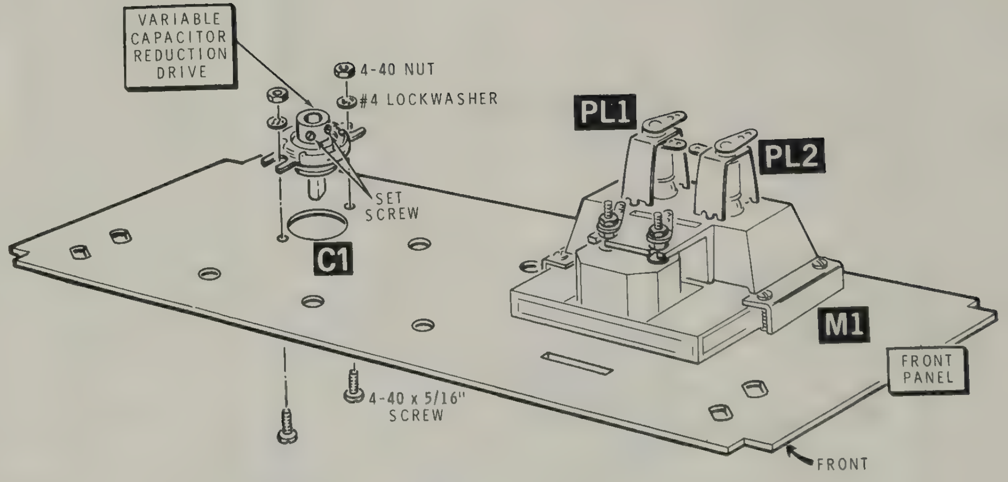
PICTORIAL 11-1



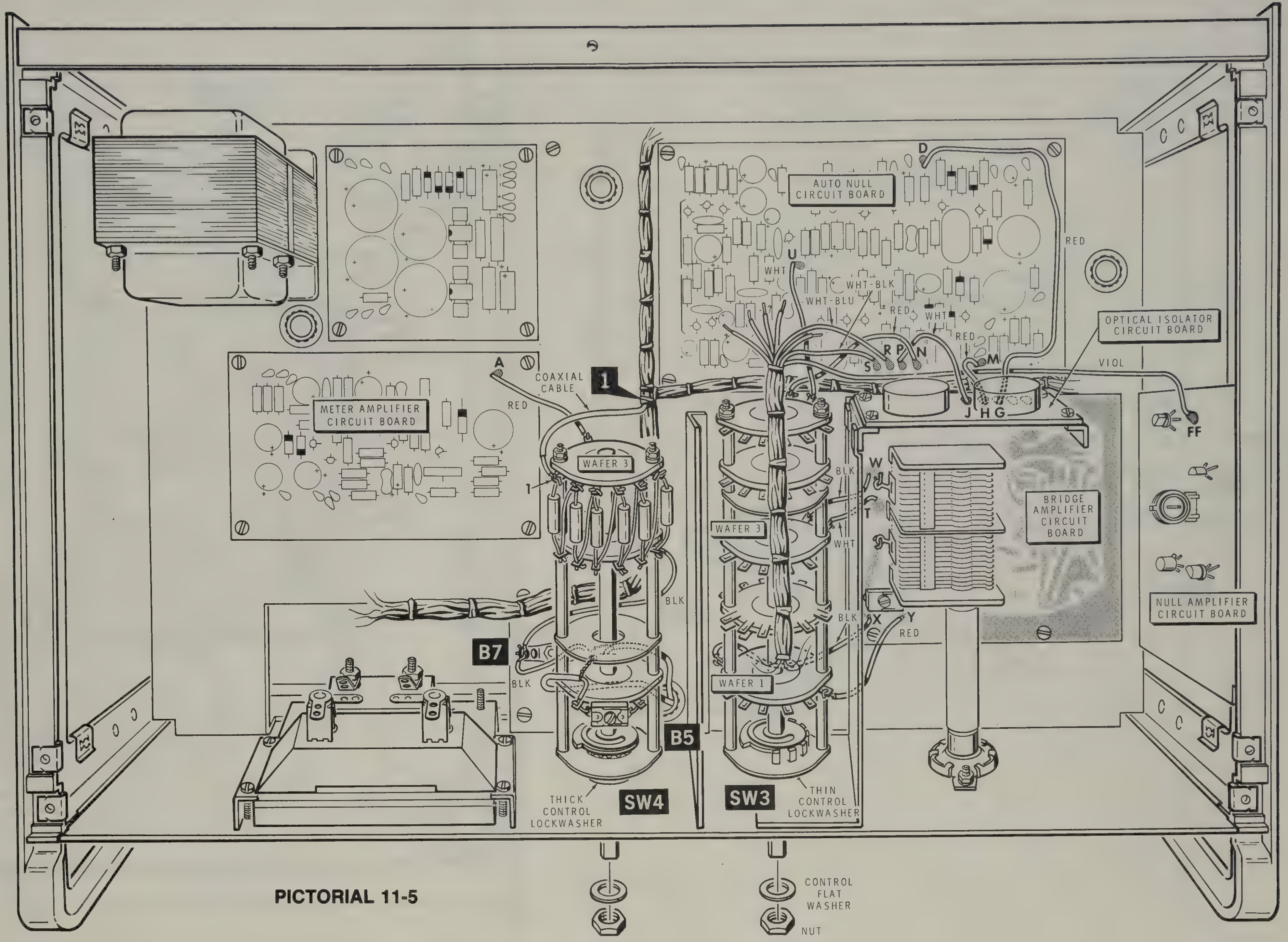
PICTORIAL 11-2


OPTICAL ISOLATOR CIRCUIT BOARD
K
1" BARE WIRE
SOLDER LUG
A
A
BARE WIRE
B
B
D
BRIDGE AMPLIFIER CIRCUIT BOARD
D
E
C111 0.047
E
M
F
BB
GG
G
G
H
H
NULL AMPLIFIER CIRCUIT BOARD
3

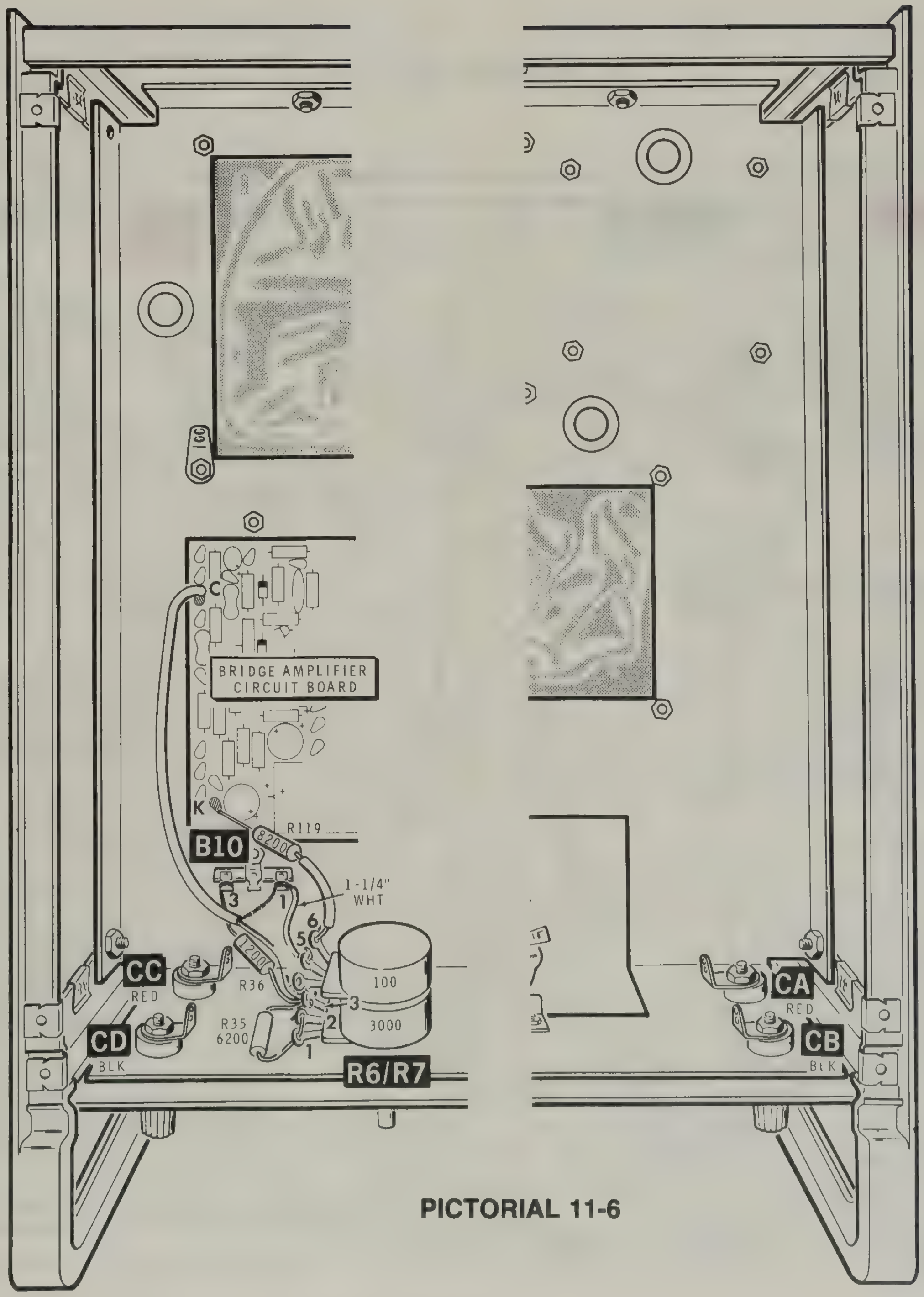
Detail 11-2E



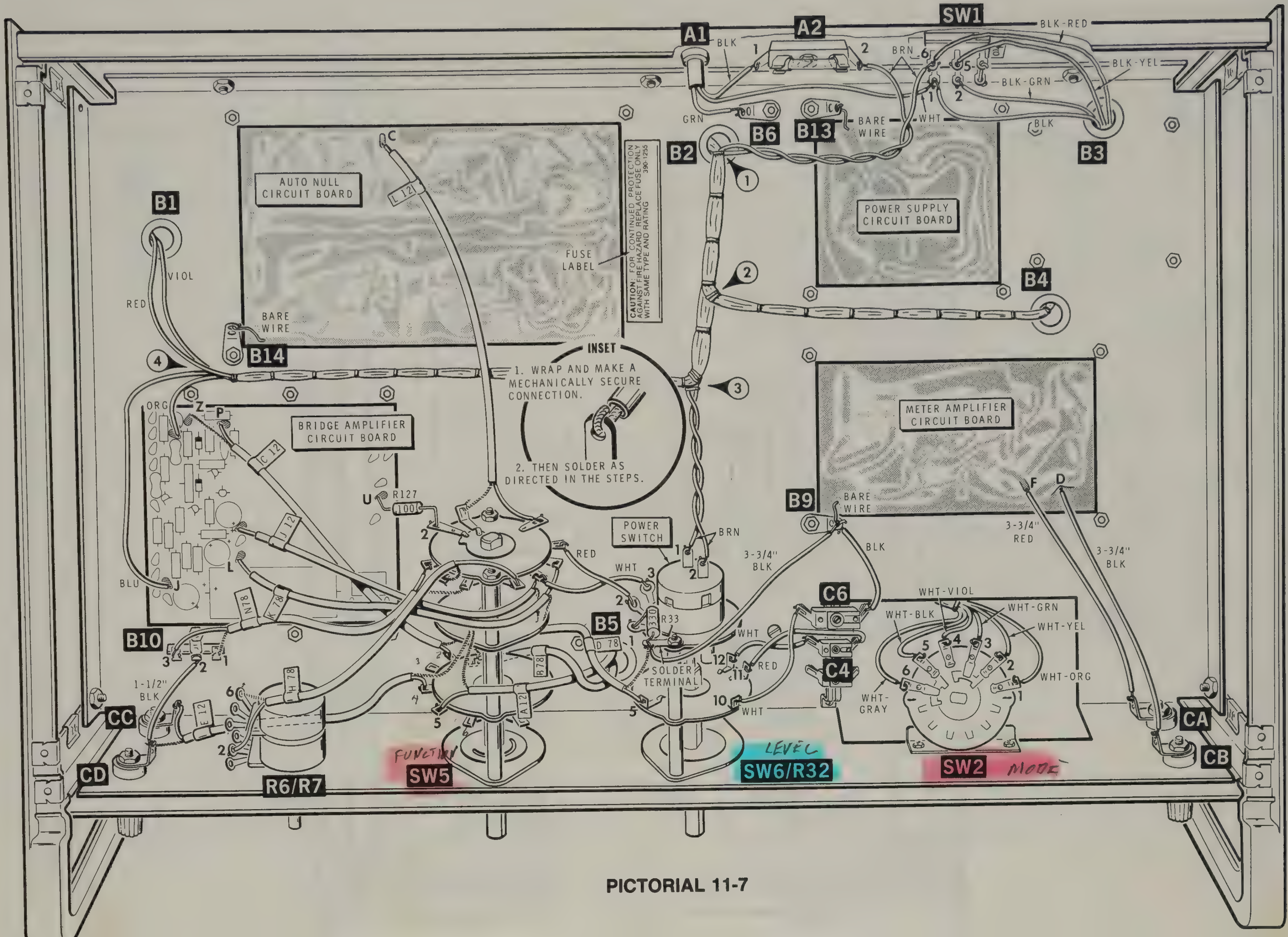
PICTORIAL 11-3



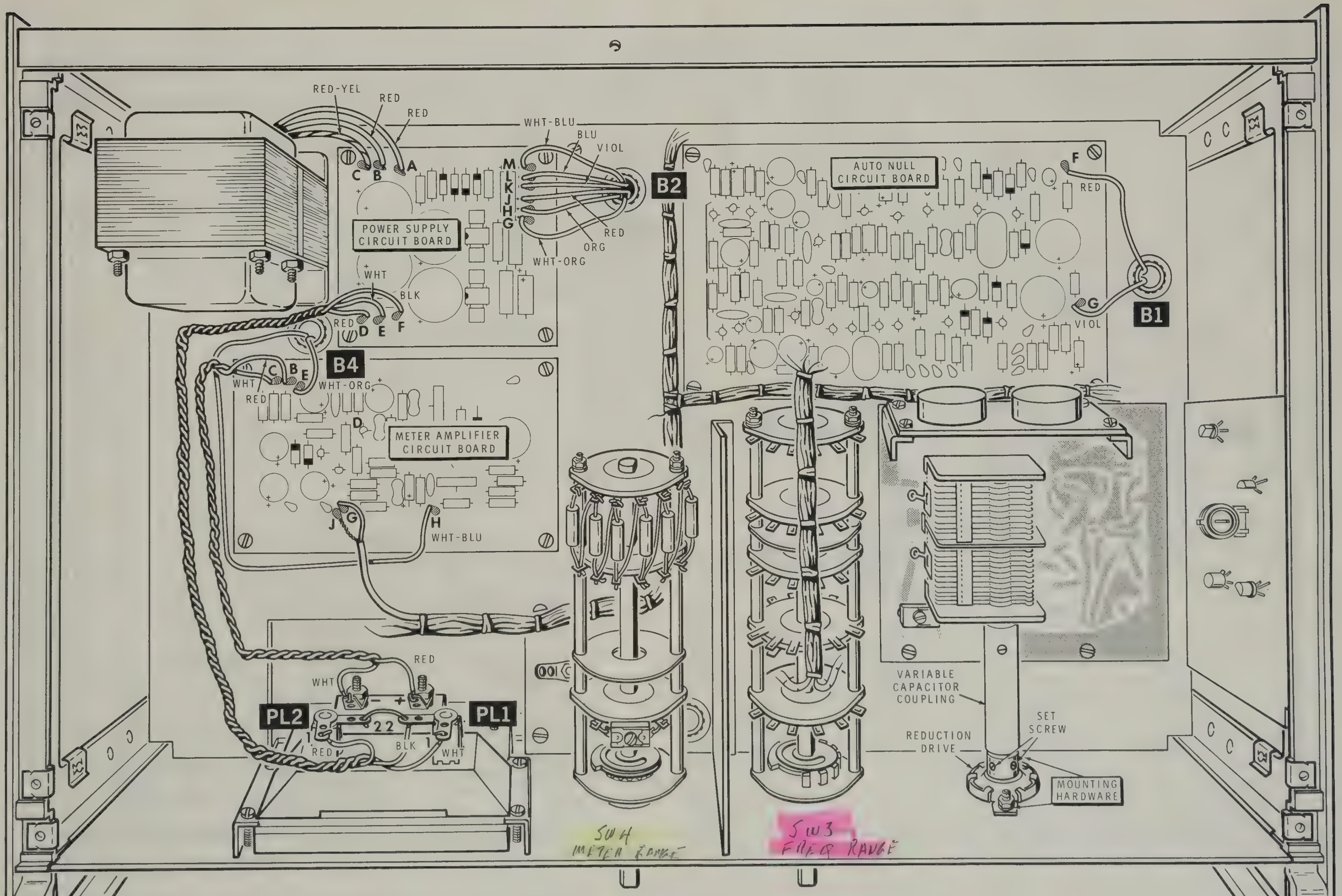
PICTORIAL 11-5



PICTORIAL 11-6


INSET
1. WRAP AND MAKE A MECHANICALLY SECURE CONNECTION.
2. THEN SOLDER AS DIRECTED IN THE STEPS.

PICTORIAL 11-7



PICTORIAL 11-8

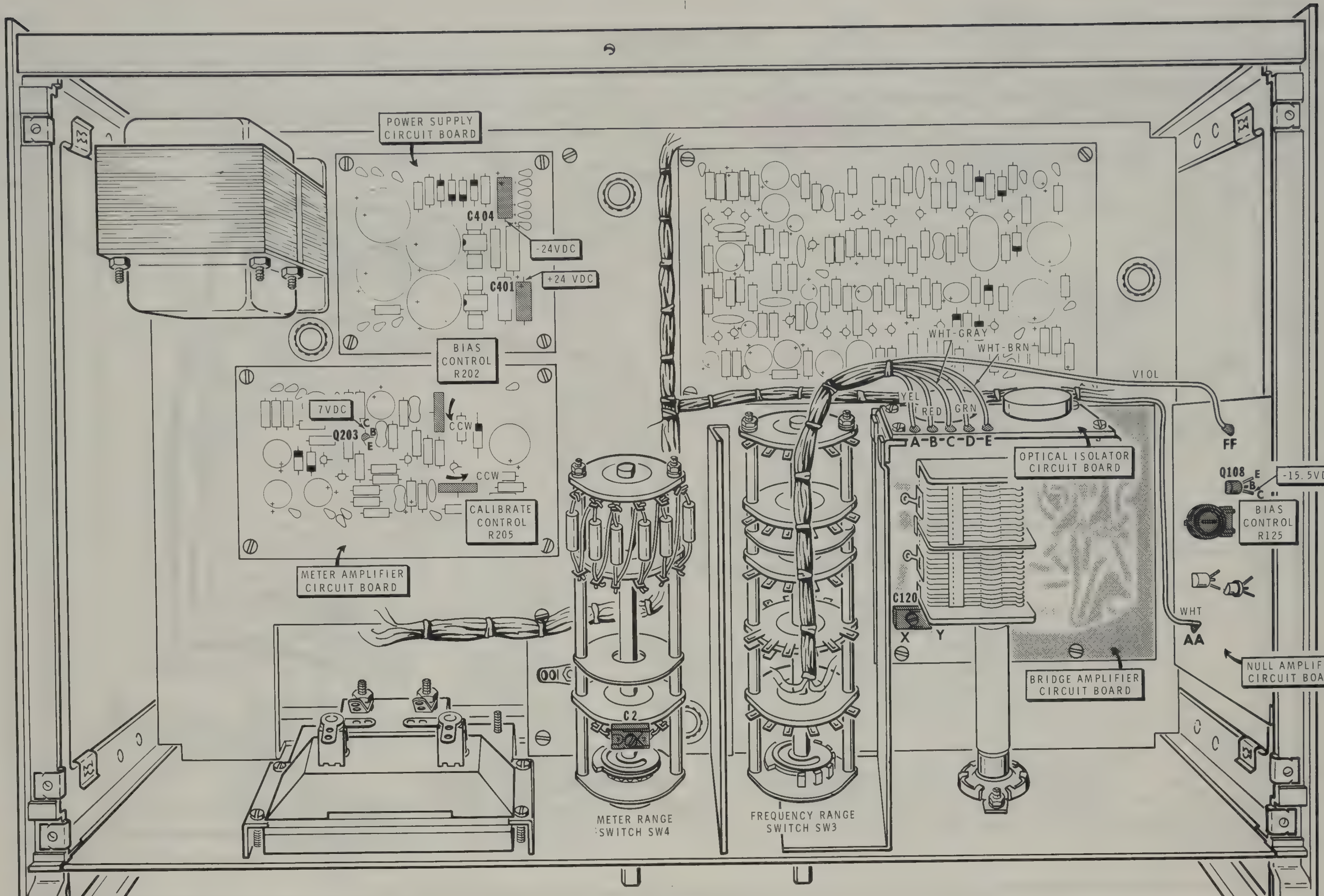

POWER SUPPLY CIRCUIT BOARD
C404
-24VDC
C401
+24 VDC
BIAS CONTROL R202
7VDC
Q203
C
B
E
CCW
CCW
CALIBRATE CONTROL R205
METER AMPLIFIER CIRCUIT BOARD
WHT-GRAY
WHT-BRN
VIOL
YEL
RED
GRN
A-B-C-D-E
OPTICAL ISOLATOR CIRCUIT BOARD
FF
Q108
E
B
C
-15.5VDC
BIAS CONTROL R125
C120
X
Y
WHT
AA
NULL AMPLIFIER CIRCUIT BOARD
BRIDGE AMPLIFIER CIRCUIT BOARD
C2
METER RANGE SWITCH SW4
FREQUENCY RANGE SWITCH SW3

Figure 1

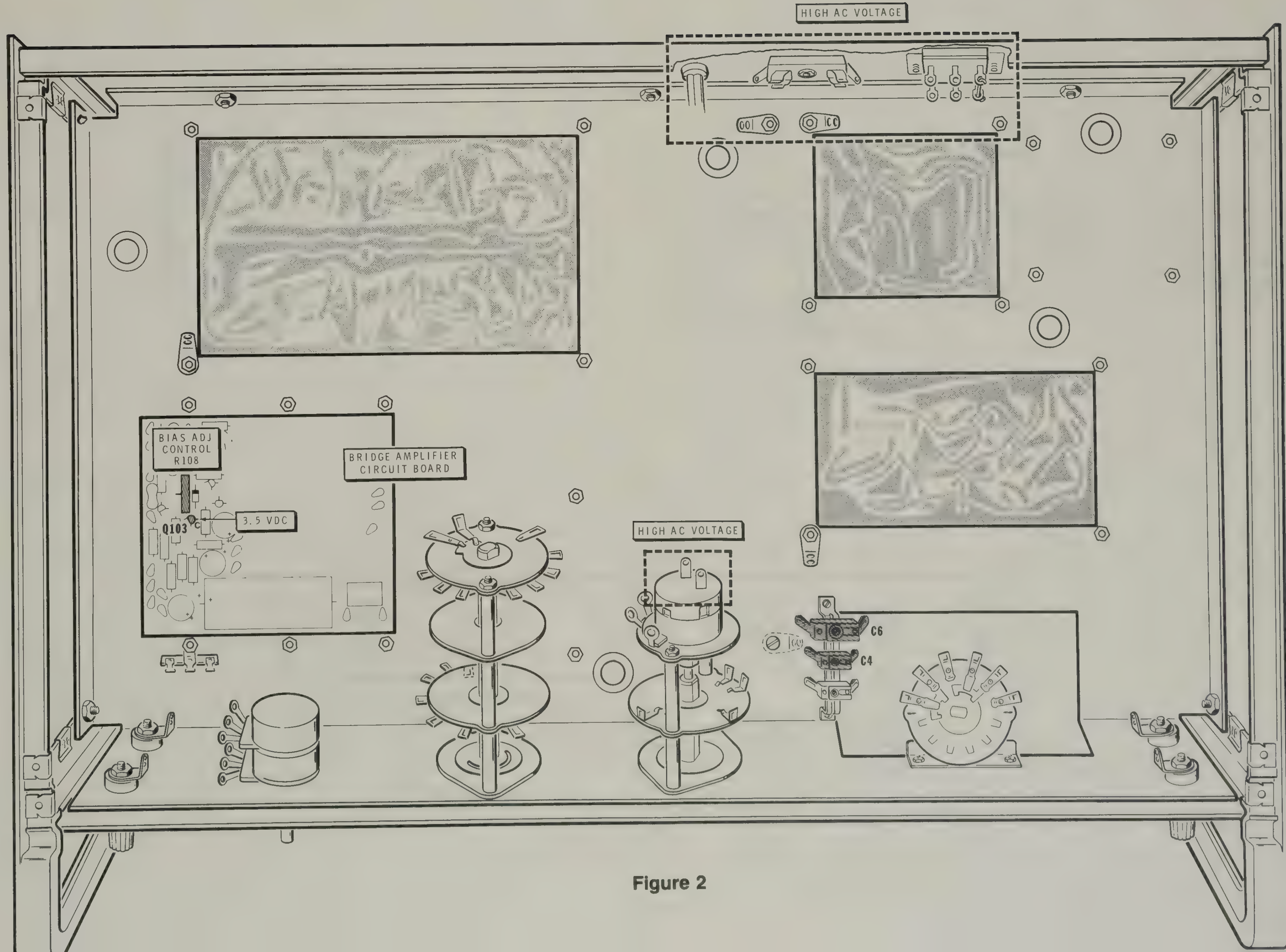

HIGH AC VOLTAGE
BIAS ADJ CONTROL R108
BRIDGE AMPLIFIER CIRCUIT BOARD
3.5 VDC
Q103
C
HIGH AC VOLTAGE
C6
C4

Figure 2

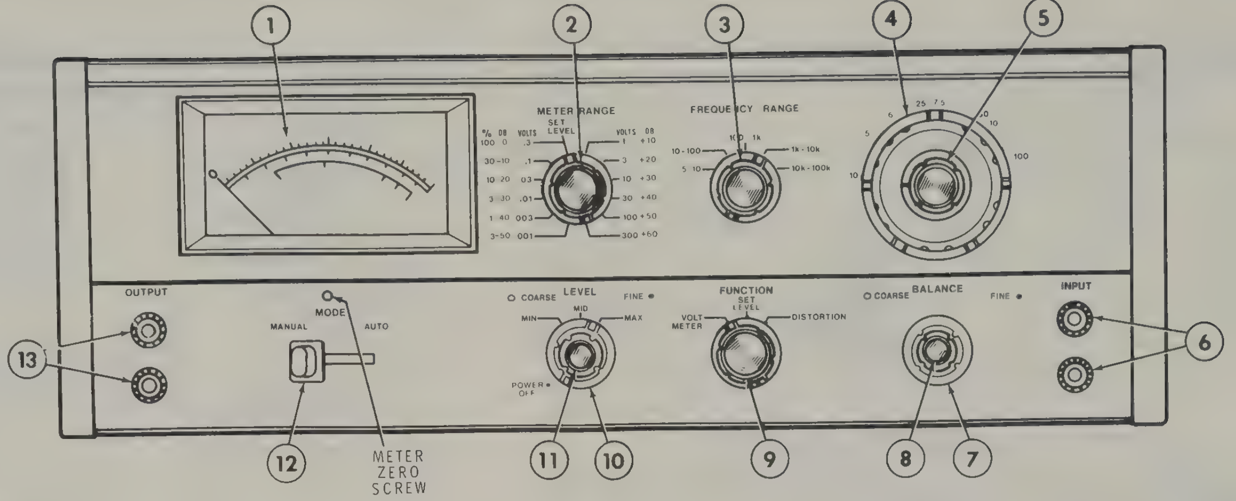


Figure 3

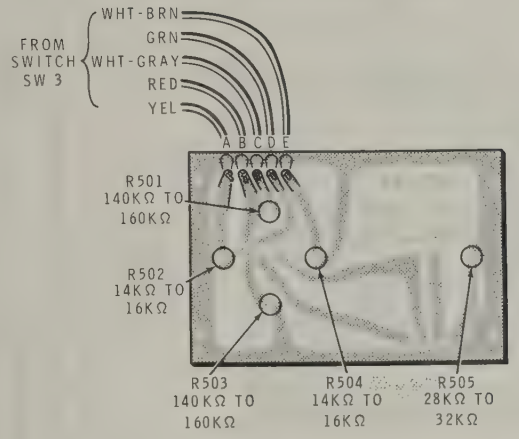


Figure 4

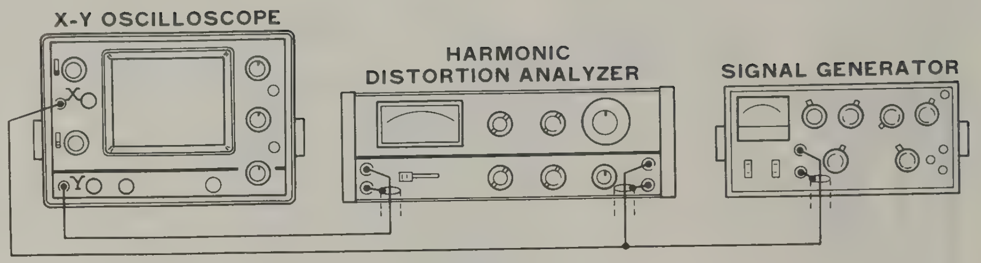
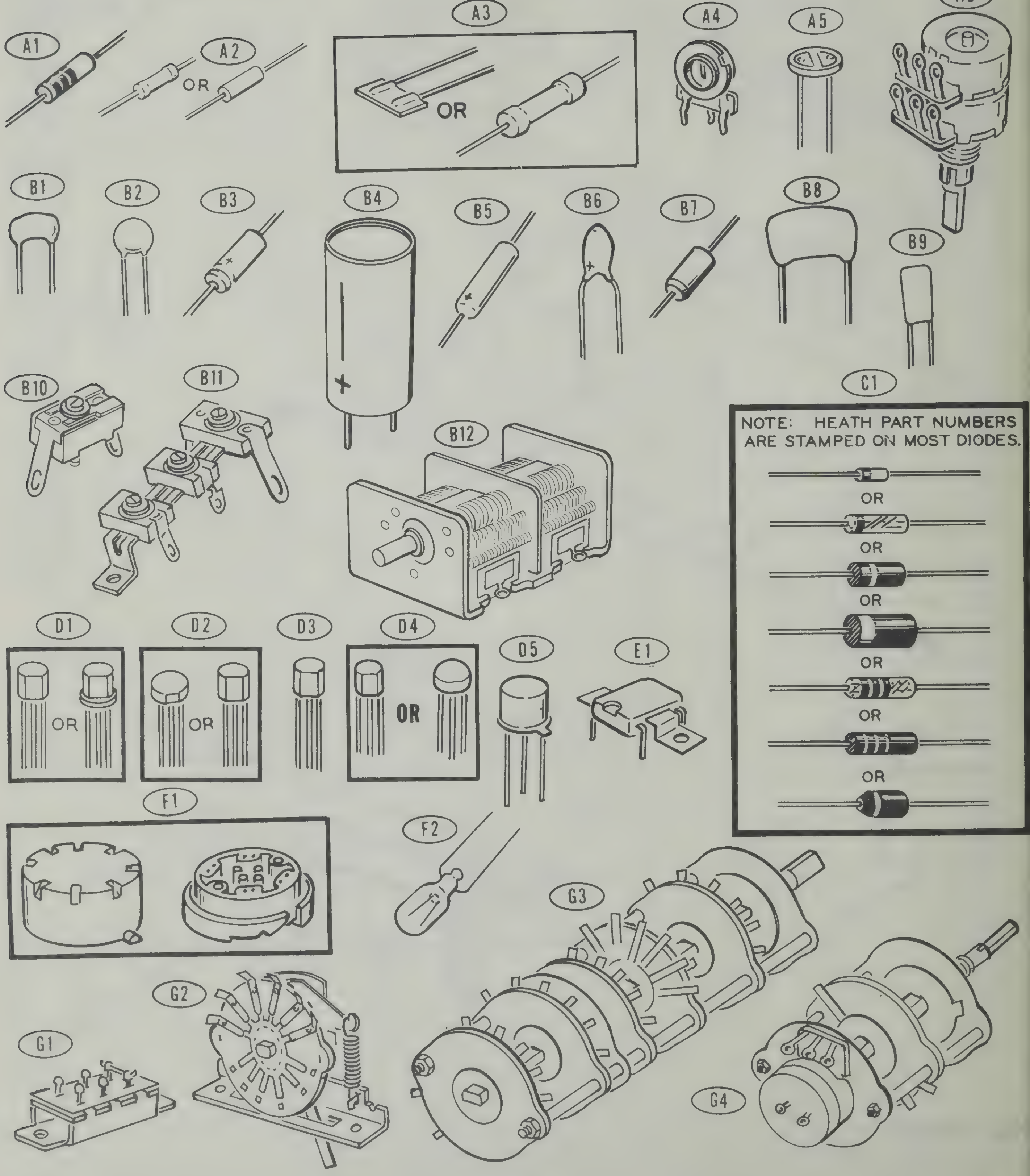


Figure 5

ILLUSTRATI

PARTS



NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES.

COMPONENT IDENTIFICATION

This section of the Manual contains "Circuit Board X-Ray Views," and "Component Identification Charts." The X-Ray Views show the location of the components. The Charts illustrate the components and list their characteristics.

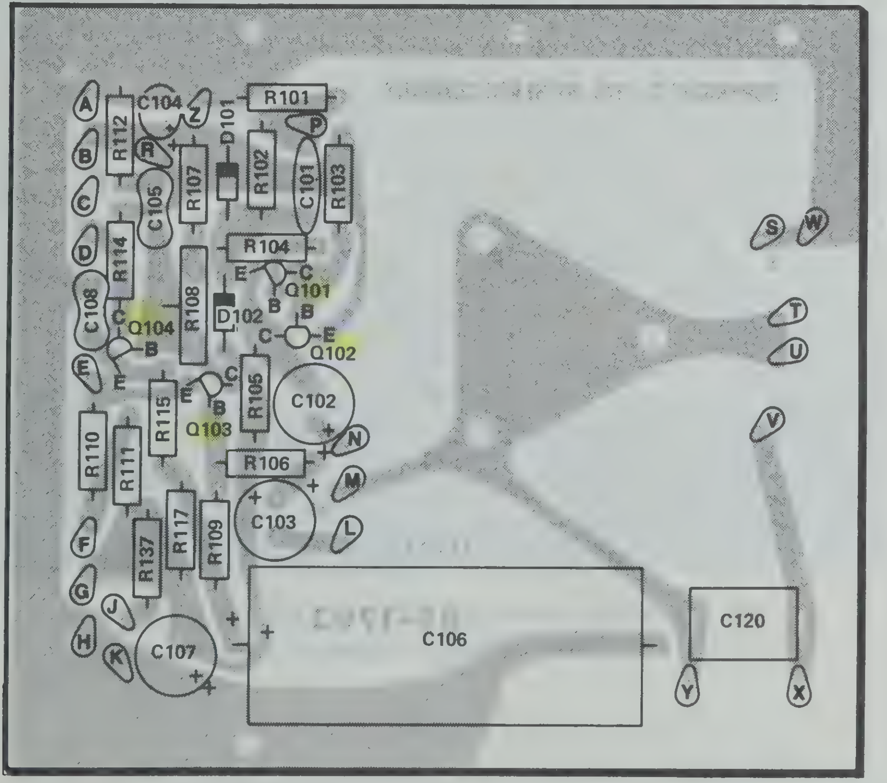
CIRCUIT BOARD X-RAY VIEWS

NOTE: To find the PART NUMBER of a component for the purpose of ordering a replacement part:

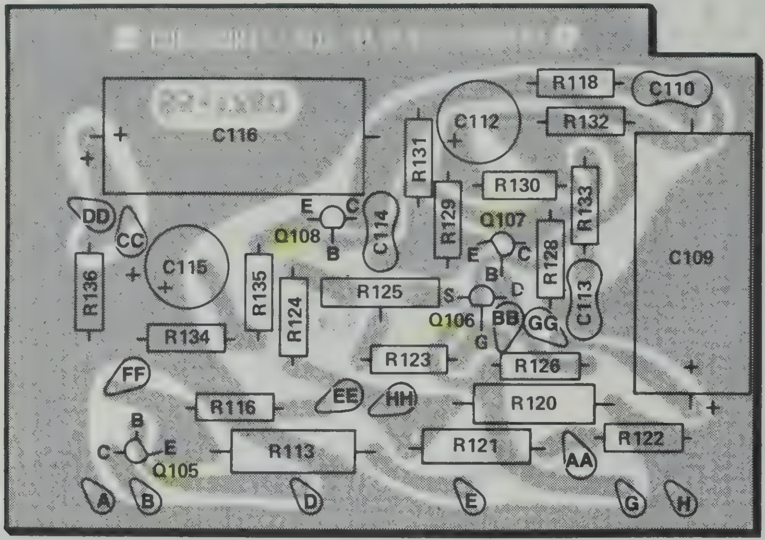
A. Find the circuit component number (R106, C101, etc.) on the X-Ray View.

B. Locate this same number in the "Circuit Component Number" column of the "Parts List."

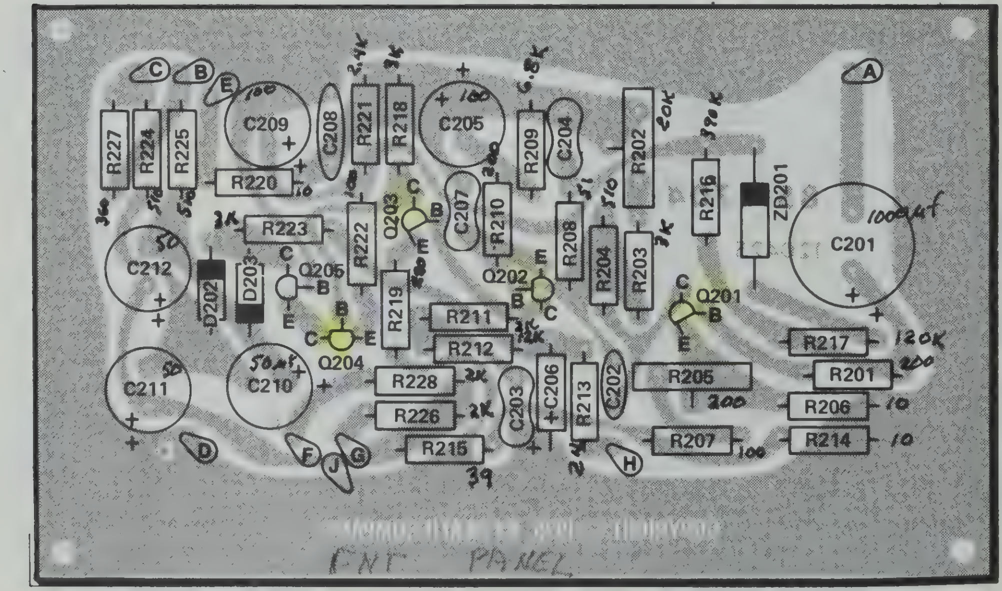
C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.



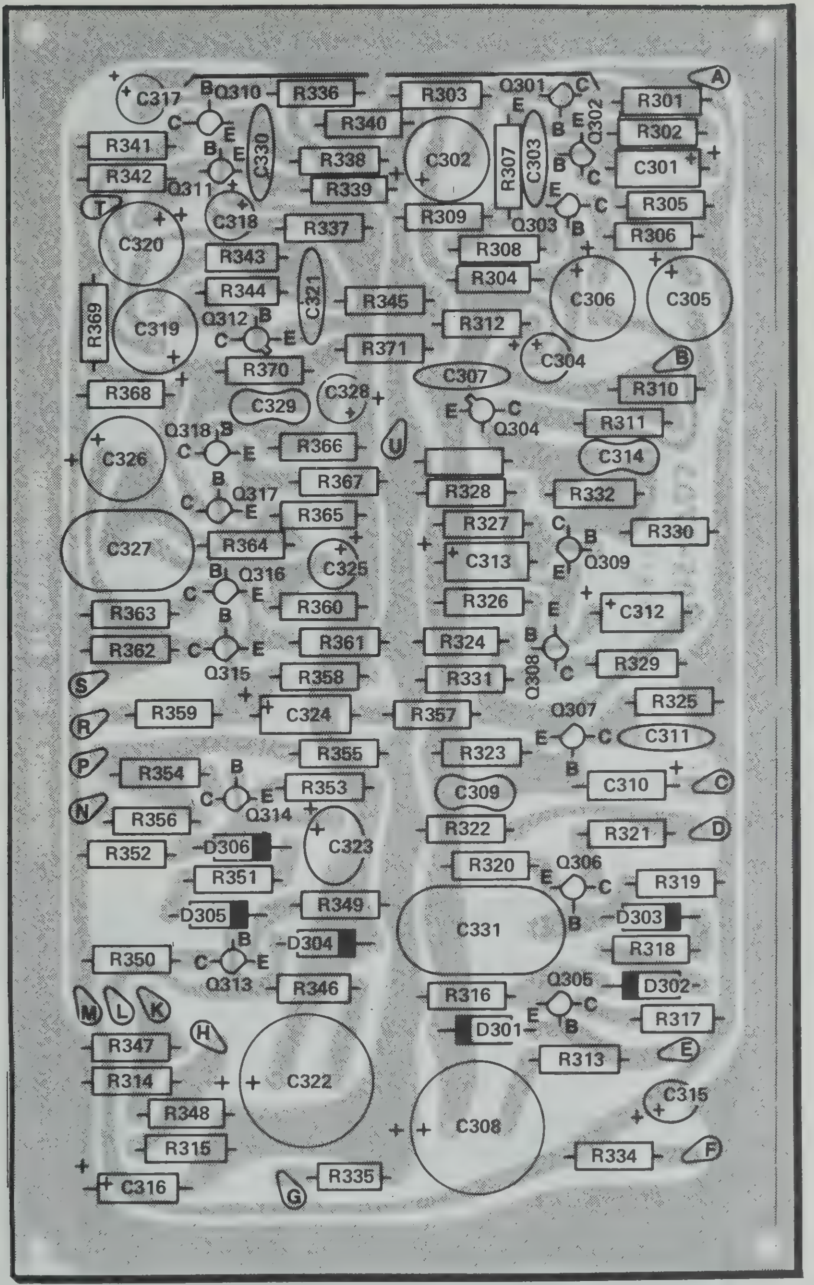
BRIDGE AMPLIFIER CIRCUIT BOARD
(Viewed from component side.)



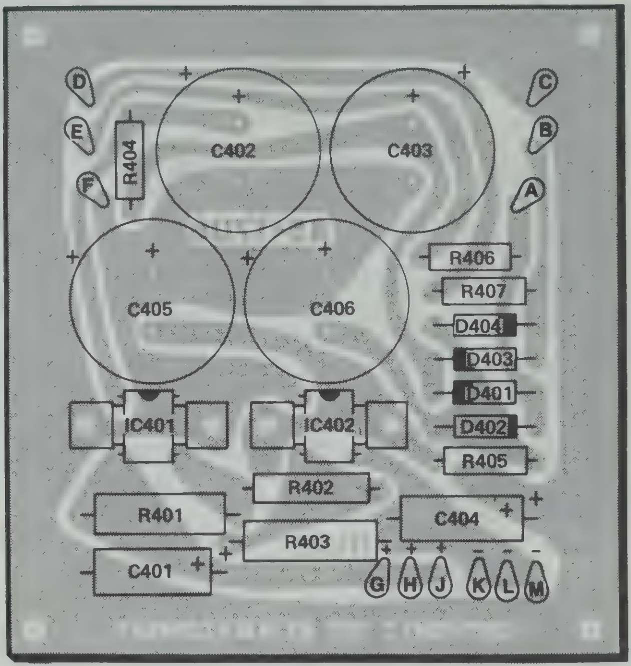
NULL AMPLIFIER CIRCUIT BOARD
(Viewed from component side.)



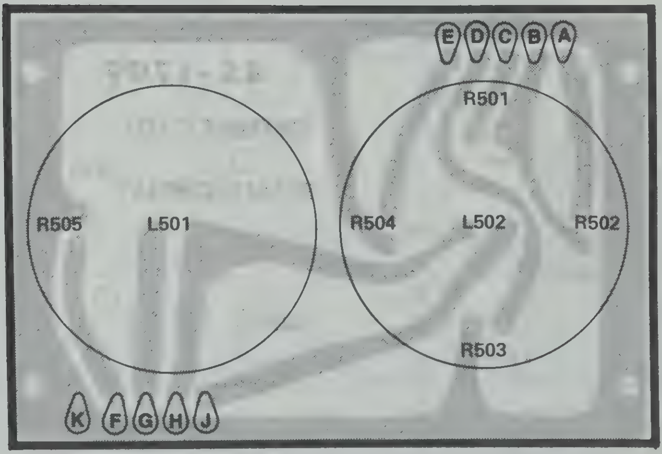
METER AMPLIFIER CIRCUIT BOARD
(Viewed from component side.)



AUTO NULL AMPLIFIER CIRCUIT BOARD
(Viewed from component side.)



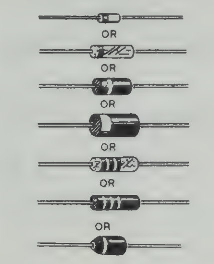
POWER SUPPLY CIRCUIT BOARD
(Viewed from component side.)



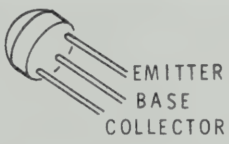
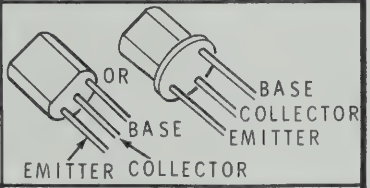
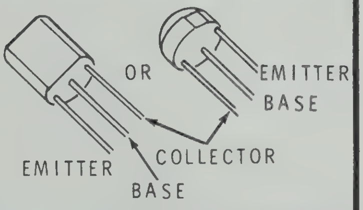
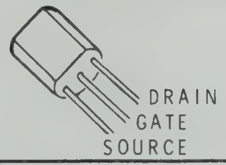
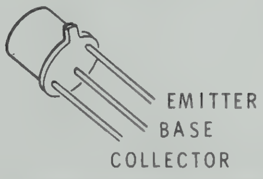
OPTICAL ISOLATOR CIRCUIT BOARD
(Viewed from component side.)

COMPONENT IDENTIFICATION CHARTS

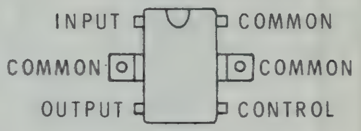
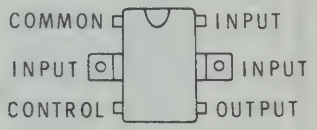
DIODES

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	DESCRIPTION	DIAGRAM
D302, D303, D305, D306,	56-24	1N458	80mA, 125V	NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES. 
ZD201	56-25	1N4166A	ZENER DIODE 17mA, 15V	
D202, D203, D301, D304,	56-26	1N191	45mA, 90V	
D101, D102,	56-56	1N4149	10mA, 75V	
D401, D402, D403, D404	57-27	1N2071	1A, 600V	

TRANSISTORS

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	BASE DIAGRAM (TOP VIEW)
Q308, Q309, Q317, Q318	417-93	2N3646	
Q103, Q104, Q105, Q107, Q201, Q203	417-94	2N3416	 OR BASE COLLECTOR EMITTER BASE EMITTER COLLECTOR
Q101	417-222	SELECTED HEATH PART	
Q102, Q108, Q202, Q204, Q205	417-235	2N4121	
Q301, Q302, Q303, Q305, Q306, Q307, Q310, Q311, Q313, Q314, Q315, Q316	417-283	SELECTED HEATH PART	
Q106	417-878	SELECTED HEATH PART	
Q304, Q312	417-886	2N2432	

INTEGRATED CIRCUITS

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	DESCRIPTION	BASE DIAGRAM (TOP VIEW)
IC401	442-617	UA78MGT2C	+24-VOLT REGULATOR	
IC402	442-618	UA79MGT2C	-24-VOLT REGULATOR	

FOR PARTS REQUESTS ONLY

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

- Please print all information requested.
- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% (25¢ minimum, $3.50 maximum) for insurance, shipping and handling. Michigan residents add 4% tax.

  Total enclosed $________
- If you prefer COD shipment, check the COD box and mail this form. COD ☐

NAME ________________________

ADDRESS ________________________

CITY ________________________

STATE ________________ ZIP ________

The information requested in the next two lines is not required when purchasing nonwarranty replacement parts, but it can help us provide you with better products in the future.

Model # ____________ Invoice # ____________

Date Purchased ____________ Location Purchased ____________

LIST **HEATH** PART NUMBER	QTY.	PRICE EACH	TOTAL PRICE

TOTAL FOR PARTS	
HANDLING AND SHIPPING	
MICHIGAN RESIDENTS ADD 4% TAX	
TOTAL AMOUNT OF ORDER	

SEND TO: **HEATH COMPANY**
BENTON HARBOR
MICHIGAN 49022
ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

CUT ALONG DOTTED LINE

FOR PARTS REQUESTS ONLY

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

- Please print all information requested.
- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% (25¢ minimum, $3.50 maximum) for insurance, shipping and handling. Michigan residents add 4% tax.

  Total enclosed $________
- If you prefer COD shipment, check the COD box and mail this form. COD ☐

NAME ________________________

ADDRESS ________________________

CITY ________________________

STATE ________________ ZIP ________

The information requested in the next two lines is not required when purchasing nonwarranty replacement parts, but it can help us provide you with better products in the future.

Model # ____________ Invoice # ____________

Date Purchased ____________ Location Purchased ____________

LIST **HEATH** PART NUMBER	QTY.	PRICE EACH	TOTAL PRICE

TOTAL FOR PARTS	
HANDLING AND SHIPPING	
MICHIGAN RESIDENTS ADD 4% TAX	
TOTAL AMOUNT OF ORDER	

SEND TO: **HEATH COMPANY**
BENTON HARBOR
MICHIGAN 49022
ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

CUSTOMER SERVICE

REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath Electronic Centers. Be certain to include the **HEATH** part number exactly as it appears in the parts list.

Replacement parts are maintained specifically to repair Heath products. Parts sales for other reasons will be declined.

ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including:

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to:
Heath Company
Benton Harbor
MI 49022
Attn: Parts Replacement

Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.

OBTAINING REPLACEMENTS FROM HEATH ELECTRONIC CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath Electronic Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath Electronic Center.

TECHNICAL CONSULTATION

Need help with your kit? — Self-Service? — Construction? — Operation? — Call or write for assistance. you'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek — please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase and invoice number.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit COD for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment. Do not include the kit Manual.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

HEATH
Schlumberger

HEATH COMPANY • BENTON HARBOR, MICHIGAN

THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM

LITHO IN U.S.A.